FP7 deliverables on textiles and cloting

# BIOFIBROCAR

Project Acronym: BIOFIBROCAR

programme & topic: FP7-SME SME-2012-1

Most frequent returning words in objectives:

* ('project', 67)
* ('fibres', 38)
* ('textile', 25)
* ('materials', 24)
* ('dissemination', 23)
* ('development', 22)
* ('properties', 22)
* ('activities', 21)
* ('partners', 21)
* ('biofibrocar', 20)
* ('products', 20)
* ('industry', 18)
* ('developed', 17)
* ('prototype', 16)
* ('work', 16)
* ('material', 15)
* ('events', 15)
* ('order', 14)
* ('requirements', 13)
* ('package', 13)
* ('website', 13)
* ('vehicle', 12)
* ('results', 12)
* ('fabrics', 11)

executive summary:  
the main objective of biofibrocar project is to manufacture textile substrates (woven or non-woven) for vehicle interiors from renewable resource-based synthetic fibres from polylactic acid derivatives that can be used as a substitute for the polyester fibres that are currently used. these biofibres must fulfil the same requirements that the fibres used at the moment including thermal resistance. biofibrocar objectives will bring innovations in textile and automotive industries. the growing importance of environmental aspects in recent years, coupled with greater public awareness is driving the development of new yarns and textile structures form within the textile industry. the possibility of using fibres from renewable resources and which are also easily biodegradable will be useful for the vehicle interior textile industry, both from the point of view of the strict new recycling regulations that these products must meet and the properties offered by this type of fibre.  
biofibrocar project has had a duration of 30 months, at the moment the project has finished successfully. during the project execution, the partnersâ efforts have been focused, first, in the review of the available materials in terms of fibres and fabrics, and their study and characterization under laboratory condition. those characterization activities assured the fulfilment of the automotive industry standards which have been collected as well by the partners. a complete list of suitable materials has already been collected.  
  
the project results in a prototype which can be used in a car door panels. this prototype was characterized and validated (see figure attached). all of the characterization trials of the prototype demonstrated that the thermal and mechanical properties of the prototype reach the same values than their homologous made of non-renewable sources (polyster) see figure of the demonstrator and prototype.  
  
project context and objectives:  
  
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the automotive sector currently generates large volumes of solid waste particularly at the end of the vehicleâs life. this makes the substitution of different plastic textile components for others that are more environmentally friendly one of the ways in which the industry is trying to reduce its environmental impact as well as adding new value-adding functionalities to new products. this initiative aims to develop much more environmentally-friendly materials, with new properties that can be used in textile components to add value but at the same time meet all current safety legislation with respect to odour and volatile particle emissions for vehicle interior components.  
  
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such innovations will be directed to maintain competitive positions in the area of technical products and technical applications, always with a high added-value. research efforts are focused on:  
  
â¢ improved recyclability of the different components that make up a vehicle, substituting polyester or polyamide for biodegradable pla.  
â¢ the development of new textiles for the car industry with improved fireproofing properties by the addition of expansion additives that improve fireproofing and therefore the safety of the vehicles.  
â¢ the application of new added value for different textile components using new additives on the fibers that have been developed. the additivation of certain compounds on the polymer chains used in the manufacture of the synthetic fibers may be one of the ways to reduce or eliminate odorsâ in vehicle interiors which are provoked by certain elements within a vehicle.  
â¢ the use of new bicomponent core/sheath textile fibers in textiles for the car industry that will improve abrasion resistance through the additivation of relatively cheap nanoparticles in the sheath.  
â¢ the development of a biocompound with the same properties as the polyesters currently used on fiber applications.  
  
the achievement of the above mentioned objectives will result in an increase of the competitiveness of the participating smes which represent the different types of smes involved in the micro-irrigation market:  
  
â¢ compounders will increase their knowledge by the use of processes that until now have not been widely developed at industrial scale, such as the structural changes between different biodegradable materials and other additives to obtain the final formulation to be processed and fulfil the requirement established.  
â¢ additivesâ manufacturer will diversify their offer by giving to their profile an added value with the achievement of the fibreâs properties such as odour less, fire-resistance, friction protection, etc.  
â¢ manufacturer who will be able to offer their customers new textile fibres with the advantage of its biodegradability, maintaining all the properties of current polyester fibres.  
â¢ weaving and laminating manufacturer will benefit from the biodegradability of the fabric substrates which will provide temperature resistance, mechanical and environmental properties.  
  
other potential sectors where smes can be benefited are, for instance; raw material manufacturers and automotive suppliers, as the development of new fibres of biodegradable material will represent the expansion of their market since these products will be used in an application where nowadays are not present; or other transport manufacturers in sectors such as aviation or trains. furthermore, the automotive sector aims to offer environmentally friendly products which help the sustainability of the planet. the biodegradable fibre developed constitutes the key point to achieve it by offering these add valued products. the smes companies will impact on the sustainable development of vehicles with its capability for weight savings, its strength and durability and its biodegradability. different recyclers will participate in recycling and biodegrading the pla fibres and contribute to avoid the landfill disposal of the products. biofibrocar can become their solution, enlarging the market share of the smes involved in the project.  
  
project results:  
obtained results  
the project results in a prototype which can be used in a car door panels. this prototype was characterized and validated (see figure attached). all of the characterization trials of the prototype demonstrated that the thermal and mechanical properties of the prototype reach the same values than their homologous made of non-renewable sources (polyster) see figure of the demonstrator and prototype.  
the project results and activities can be structured attending to the workpackage in which have been carried.  
  
work package 1 definition of requirements and selection of materials   
wp 1 included an exhaustive study concerning the requirements for the products developed during this work package: the used materials, their transformation, processing and the experiments employed. it defined the principal materials to be used throughout the project for experimental trials and included furthermore a comprehensive state-of-the-art analysis of the filaments and fibres to be chosen and provided a structured basis for the research and development activities by identifying and validating the filaments and fibres suitable for the fabric production (wovens and nonwovens) in the subsequent work packages. the most suitable filaments, fibres and fibre blends as well as the most suitable fabric structures and their best production technologies were selected. at first, basic studies on pla (polylactic acid) fibres and filaments and requirements on their properties and temperature behaviour in the manufacturing process and during the life time cycle were of essential interest. textile substrates (wovens and nonwovens) for car interiors from renewable resource-based synthetic pla materials were identified which to be used as substitute for currently applied fibres or filaments. woven fabrics were produced from yarns made of 100 % pla filaments. different yarn constructions (for instance core-sheath) were investigated for different applications such as decorative fabrics. two main directions had to be taken into consideration for nonwoven structures: the first was to produce nonwovens of 100 % pla fibres to be applied as soft touch layer (as sound absorbing material for composite structures in door panels) and secondly to use thermoplastic pla fibres in blends with natural fibres (such as hemp) for moulded parts (doors panels). investigations in expected side-effects which might be occurring (such as odour, flammability or reduction in weight) have been also part of this wp. the final part mainly regarded to the materials selection and the processing, transformation and experimental techniques to be used. at the end of wp1, a decision on the fibres, filaments and textile structures that are finally applied were defined on the basis of all gathered requirements and information. these findings were needed for the correct execution of the project as well as for wp2 and wp3 both of them focused on the development of the biodegradable thermoplastic fibres and the pla compounding. finally, the structure for a demonstrator was developed and first sample demonstrators were produced in wp1. findings of wp1 have been also the basis for wp4 (optimization of biodegradable fabrics).   
  
work package 2 development of the base pla compound for textile production.  
in wp2 it is included all aspects related to the development of the new pla based biocompound: selection of the best additives, materials and its combinations, selection of the best equipment, processability of these different materials in order to obtain the final compound, optimization of this process and the machine parameters, etc. this pla based compound is the base material of the new biofibres comprising the prototype developed in the biofibrocar project.  
during the first period of the project, efforts were focused on the development and improvement of the best materials combinations (blends). first trials with selected materials were carried out and, even the thermal resistance was successfully increased, different problems were observed.   
in the second period different approaches were followed for the development of the compounds in order to achieve the desired properties. however, some of the were due to different problems, and new approaches not foreseen initially in the project, were included.  
  
work package 3 development/optimisation of biodegradable thermoplastic fibres  
  
workpackage 3 consists of establishing the parameters (temperature and velocity) that will be adjusted to suit requirements established in work package 1 for yarns to woven and nonwovens, employing diverse analytical techniques to achieve these requirements, to meet the requirements for yarns (for woven and nonwovens).   
  
the main objectives of the work package 3 âdevelopment/optimisation of biodegradable thermoplastic fibresâ were:  
  
â¢ the development of biodegradable synthetic textile fibres from different pla compounds using melt spinning.  
â¢ the manufacture of pla-based core-sheath fibres with improved abrasion resistance from the different nano compounds prepared in the previous stage.  
â¢ the functionalisation of different pla fibres, by the additivation of pla polymers with odour-absorbing particles or with improved fireproofing capability, to produce innovative automobile fibres.  
  
the above objectives were achieved during the first project period (m1-m12) and were continued and extended by the following activities in the second project period from m13-m30:  
  
â¢ the main objective is to develop new pla-based fibres chemically modified or blended with other biopolymers, with the aim of enhancing their thermal properties using a highly crystallised polymer to increase its vicat temperature (over 100âºc).  
â¢ fibre is a functionalisation with different additives to avoid undesirable odours from the fibre.  
  
after the different blends or compounds have been manufactured and analysed in the previous wp2, the compounds that are most appropriate to be spun into fibres, and that will offer the best possible results were identified. these compounds were developed into fibres (using a pilot extrusion plant). once this was achieved, the fibres were analysed mechanically and optically to establish comparisons between them and existing textile fibres (non-renewable origin).  
  
work package 4 development / optimisation of biodegradable fabrics  
pla-phb blends and stereocomplex pla were successfully spun into filaments and further developed into fabrics and nonwovens (wp3). the trials in the project biofibrocar for the development of woven and nonwoven prototypes from pla fibres have been successfully witin wp4.   
  
the prototypes have been manufactured with the parameters of the reference products in the automotive industry in consultation with the industry partners. the prototypes have been tested for their mechanical and functional properties and benchmarked against the reference products for requirements in the automotive industry.   
  
the mechanical performance of the stereocomplex pla has found to be superior to the reference polyester fabrics. the abrasion, pilling, light fastness and flammability are above the requirements of the automotive industry. therefore, the reference fabrics have a potential for application in the automotive industry as seat cover fabrics.  
furthermore, a demonstrator door panel has been developed with the nonwoven and woven fabric developed in this work package  
  
work package 5 environmental, economic and regulatory studies.  
wp5 comprises an exhaustive study concerning environmental aspects, economic analysis and regulatory issues of the products developed during the biofibrocar project.  
environmental study.  
the methodology selected in order to analyze the environmental impact of the new biodegradable fibers developed has been the lca (life-cycle assessment). this is a technique that takes into account all the stages of a productâs life from cradle to grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling).   
  
analysis of the new thermoplastics fibersâ recyclability.   
as recyclability is a very important property on plastic material, the regrinding tests carried out in this task have been oriented to study the reprocessability of industrial scrap. furthermore, this issue is very critical for pla because this material is highly sensible to degradation and loss of rheological properties.  
test have been performed in order to establish if the recycled material may be incorporated to some extent, without influencing negatively the properties of new materials. different experiments were carried out on developed biocompound and on 100% grinded scrap.  
samples obtained were characterized and results showed a small decrease in mfi and vicat temperature, as a consequence of thermal degradation suffered by the material during reprocessing. however, the difference is small and mfi and thermal resistance were still suitable for ems process and accomplish automotive applications requirements.  
  
evaluation of biodegradation of the full textile substrates in laboratory scale test.   
in order to verify the biodegradable condition of the new developments (compound/fibres/prototype), test samples were evaluated according to the standards en 13432:2000, specifically the iso 14855-1:2005 âdetermination of the ultimate aerobic biodegradability of plastic materials under controlled composting conditions â method by analysis of evolved carbon dioxide â part 1: general methodâ.  
two different samples were evaluated:  
- sample 1: carded nonwoven of cross-linked compound obtained during the first period of the project.  
- sample 2: carded nonwoven prototype made with final formulation selected.  
  
criterion: > 90% absolute or relative biodegradation.  
both samples showed biodegradation percentages > 90% under composting conditions after 80-85 days, so both of them are biodegradable.  
furthermore, as sample 1 contained zn in its composition, a zinc metal analysis has been done in order to check the amount of metal present in the formulation.  
economic analysis.  
in order to evaluate the economic viability of the prototype developed, a study of material and product costs has been done. only the final pla formulation selected has been assessed to make an estimation of the product cost.  
the evaluation has been carried out taking into account the price of the commercial components used for the elaboration of the different layers of the prototype and the processing cost data at pilot plant level. however, aspects like disposal and removal cost and market evolution have been taken into account. the results have been compared with reference material currently used for car interior components.  
regulatory analysis.  
since the new developments of biofibrocar project (fibres/door panel) have to fulfil the related ec directives for automotive components, a compilation of these directives has been collected and presented into a report. each partner and rtd has collaborated in this task in order to have represented the entire value chain of the products.  
european regulations (reach regulation), specific regulations for the development of car parts provided by validator partners, and end-of-life vehicles aspects have been taken into account.  
safety issues.  
in order to complete the regulatory analysis, definition of safety criteria has been carried out. all standards and legislation aspects related to the new fibres/prototype, like voc emissions or formaldehyde content, has been considered. all the information has been gathered in d5.16.  
  
work package 6 industrial scale up and product validation.  
  
in work package 6, we developed and produced the different prototypes using the textile fibres and fabrics developed in the previous work packages and taking into account the technical specifications required for this equipment. these prototypes have been tested and analysed according to the standards relevant to this kind of article.  
the main objectives of the work package 6 âindustrial scale up and product validationâ were:  
â¢ the transfer of the processes developed to an industrial scale.  
â¢ the development of the first industrial-scale prototypes.  
the activities planned in wp6 were subdivided into different tasks:  
  
prototype development  
in this task, all the partners were charge on the development, design and manufacture of different articles and products on an industrial scale, that served as prototypes and that possessed innovative functional characteristics for the car industry and in particular, for vehicle interiors.  
  
characterisation  
a battery of tests were performed on the prototypes installed in vehicles, to evaluate the prototype performance  
work package 7 training, dissemination and exploitation of results.  
  
dissemination of the project helps to increase the opportunities of exploitation of the foreground generated in biofibrocar project. the definition and implementation of an efficient dissemination strategy that will ensure the eu industry awareness of the project developments were one of the activities performed during the first period of the project. also a draft version of plan of the use and dissemination of the foreground and different activities were carried out by the different partners of the consortium.  
in this second period a final version of the pudf was drawn up. all dissemination activities have been compiled and included in it. the document provides a detailed overview of all dissemination activities carried out in the lifetime of the project. also gives a general view of the exploitable project results and related planned exploitation activities of the partners.  
  
different activities like training events and redaction of a best practices guideline have been carried out in order to make an effective transmission of the information obtained during the project. in order to ensure the efficient technology transfer of the biofibrocar project developments a set of training events have been imparted to train the technical staff of the smes. the idea was to transmit the information obtained during the project (materials, structures, processes) with these training activities. each rtd performer prepared a set of training materials (powerpoint/pdf presentations) based on the results achieved and the trials performed in the project.  
  
potential impact:  
the first concern of the sme participants within biofibrocar is that the project resulted in strengthening their own competitiveness and resulte in a growth in volume, turnover and profit margins based on the novel products that can make the difference in the economic environment.   
there are indeed good foresights that the envisioned products and processes will become a success.   
first of all, it must however be quoted that the project is not specificly aiming at a âreduced cost productâ if compared to standard bedding products. competing at such a level seems quite impossible for the european textile manufacturers, given the strong competition from developing countries. instead, biofibrocar, targets high added value products of high quality, which are healthy to use for consumers and which have a high eco-friendly aspect.   
these latter aspects, ecological and human safety concern are the main drivers for the project and were the basis for starting the project. the presence of potentially toxic products in current bedding materials is a major concern within the community and more and more end-users are asking for safe alternatives.  
the use of a new materials which are gaining a foothold in the textile industry in applications where recyclability is limited owing to the presence of plastic-mix materials and where biodegradability and composting may be important, without adversely affecting the productâs properties.   
  
the objectives achieved by using biodegradable materials in the car industry are summed up as follows:  
  
â¢ the development of more environmentally-friendly products and processes.  
â¢ the development of processes that allow the use of alternative raw materials to petroleum-based ones, with the consequent reduction in greenhouse gas emissions.  
â¢ the manufacture of fibres with similar properties to polyester-based ones.  
â¢ pla density is lower than that of pet so the total weight of the artefact is smaller.  
  
research has been focussed on the modification of pla-based polymer formulations for textile applications in the following areas:  
  
- the improvements of the abrasion resistant properties in fabrics designed for vehicle interiors.  
- the improvements of the fireproofing and fire behavioural properties in non-wovens used in side panels in vehicle interiors through the incorporation of different types of anti-corrosive additives and nanoparticles with enhanced effects.  
- increases in temperature resistance of existing pla fibres using reactive extrusion.  
- reductions in odours, whether by the inherent properties of the fibres themselves or by functionalising them to absorb internal odours generated inside the vehicle.  
- the development of pla-based bicomponents to improve technical aspects such as strength vs. abrasion, mechanical properties and even reductions.  
  
the dissemination activities of the project have been consistent with the originally planned dissemination activities of the project proposal. the partners, as depicted inbelow, have used an array of mediums and tools in order to successfully disseminate the project to the relevant audience. the presentation of prototypes and other relevant technology has been available for partners and has been promoted to customers and other stakeholders. in order to raise public awareness of the proposed technology, the partners have performed pre-marketing stimulation activities such as editorials, conference papers, sales, presentation in fairs and marketing contact with potential customers internationally, through the use of trade press, trade bodies and plant suppliers, approvals bodies, consumer groups and regulatory authorities. activities include technology demonstration events, major exhibitions, stimulation events, presentations and conference papers, databases and the distribution of project promotional material.  
dissemination activities were made through various communication channels; the main instruments and media that were used for dissemination purposes fall within the following areas:  
a) events (see section 2.2.1)  
events refer to both collaboration and dissemination and include participation in, or organisation of:  
â¢ presentation at conferences  
â¢ workshop for the key stakeholders  
â¢ exhibitions, trade fairs  
â¢ training events  
â¢ networking sessions  
â¢ specialised events  
b) publications (see section 2.2.2)  
publications refer to both electronic and printed media, including:  
â¢ press releases  
â¢ short articles published on the internet or in journals and relevant magazines  
â¢ newsletters and other information material produced by the partners  
â¢ papers published and presented in conferences  
c) electronic media (see section 2.2.3)  
electronic media is primarily concerned with the projectâs website and the services made available there:  
â¢ content published on the biofibrocar website  
â¢ content published on the partnersâ company website about the biofibrocar project  
2.2.1 events   
the project was noted with overall success in relation to the participation of the partners in events. a variety of different events took place such as conferences, participation in exhibitions and fairs as well as participation in seminars. the technology of the project has been presented thoroughly and throughout these events, with the partners aiming at maximizing the visibility of the project. the events helped to promote the project towards targeted audiences via personal fair stands and promotional material.   
in relation to external conferences, the partners have participated in world-renowned conferences such as: see table 1.  
specific mention must be made in relation to the type of audience each event was targeted, since the dissemination activities performed approached an array of interested parties, coming from different fields and areas of interest. universities and academic institutions, technology institutes and industrial partners are some examples of the type of audience the dissemination activities aimed at. specifically for industrial partner, it is notable to mention that events took place such as participation in conferences, fairs and exhibitions satisfying industry.  
as far as project meetings are concerned, the partners met three meetings, as prescribed within the project proposal. the first meeting (kick off meeting) took place in alcoy spain, in january 2013, where the partners had the opportunity to present their organizations, describe their involvement in the project and launch the definition of the user requirements with the active involvement of the end users. the second meeting (m6 meeting) took place in nijverdal, netherlands in july 2013. the third meeting took place in valencia (m12 meeting). the fourth took place in chemitz (m18 meeting). the fifth took place in aachen (m24) eventually, the final meeting will be held at aitex facilities in june. the partners had the opportunity to comment on the work progress and establish internal deadlines. dissemination and exploitation workshop was also established on this meeting and several telephone conferences between the partners served as a follow up to ensure that all aspects of dissemination and exploitation activities are carefully taken into consideration..   
2.2.2 publications   
publications, either in the form of press releases or as scientific papers with the intention of being published and/or in the process of being published, have played a significant role in the dissemination of the project. the project has been disseminated in various newspaper articles, both in hard copy and on the internet. many articles published concerned the distribution of the projectâs press release in notable magazines, scientific journals and industrial blogs.   
press releases were aimed primarily at the local audience, particularly professionals and industrial stakeholders. this medium has proved particularly useful since it has disseminated the project at large to a wide public which would not be easily identified via standardized methods of dissemination such as events and scientific conferences. all partners have maximized the potential for dissemination and visibility via the projectâs press release. as it can be depicted in table 1: list of dissemination activities, a variety of academic, online and popular journals have published the biofibrocar press release  
2.2.3 web sites  
the project website (http://biofibrocar.aitex.es/) acts as a dissemination platform with the aim to establish an efficient and effective dissemination and communication tool for the biofibrocar consortium for the duration of the project. the website construction consists of one of the main dissemination tools of the project, which will ensure the successful use of project results and non-confidential information to the widest possible audience (including the industrial and academic community). the website has a clear structure with two types of webpage navigation depending on the type of user i.e. visitor (public), consortium member or representative of the european commission (members area). the potentials for navigation, document uploading and website alterations differ for each type of user. the aim of the website is on one hand to inform general public about the biofibrocar project and on the other hand to constitute a tool to communicate and to exchange information on the project between partners. the technical management of the biofibrocar website belongs to the project coordinator, aitex. the project coordinator updates the website, inserts data and generally regulates the methodology for technically managing the website. technical management is implemented through the content management system and also includes the registration of the website addresses and regular renewal of the subscription as well as any necessary arrangements for the website hosting, including the 2 gb storage capacity in order to ensure that all necessary documents are properly stored either in the public documents area or in the members area.   
for the purpose of effectively disseminating the project, the following materials were produced:  
â¢ project logo: a project logo has been designed at the beginning of the project to be used in all dissemination material to enhance easy identification of the project among the members of the target groups. this logo can serve, as well, as product logo in the post-project phase (annex 1).   
â¢ project leaflet: a three-fold project brochure has been created; it describes the consortium partners and provides their main contact details as well as the general and technical objectives of the project. the brochure is user-friendly, compact and easy to understand (annex 2).  
during the first period of reporting a draft of the exploitable foreground was elaborated. at that moment, the exploitable foreground that the consortium foresaw was gathered in the pudf.  
  
list of websites:  
http://biofibrocar.aitex.es/

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â¢ manufacturer who will be able to offer their customers new textile fibres with the advantage of its biodegradability, maintaining all the properties of current polyester fibres.  
â¢ weaving and laminating manufacturer will benefit from the biodegradability of the fabric substrates which will provide temperature resistance, mechanical and environmental properties.  
  
other potential sectors where smes can be benefited are, for instance; raw material manufacturers and automotive suppliers, as the development of new fibres of biodegradable material will represent the expansion of their market since these products will be used in an application where nowadays are not present; or other transport manufacturers in sectors such as aviation or trains. furthermore, the automotive sector aims to offer environmentally friendly products which help the sustainability of the planet. the biodegradable fibre developed constitutes the key point to achieve it by offering these add valued products. the smes companies will impact on the sustainable development of vehicles with its capability for weight savings, its strength and durability and its biodegradability. different recyclers will participate in recycling and biodegrading the pla fibres and contribute to avoid the landfill disposal of the products. biofibrocar can become their solution, enlarging the market share of the smes involved in the project.  
  
project results:  
obtained results  
the project results in a prototype which can be used in a car door panels. this prototype was characterized and validated (see figure attached). all of the characterization trials of the prototype demonstrated that the thermal and mechanical properties of the prototype reach the same values than their homologous made of non-renewable sources (polyster) see figure of the demonstrator and prototype.  
the project results and activities can be structured attending to the workpackage in which have been carried.  
  
work package 1 definition of requirements and selection of materials   
wp 1 included an exhaustive study concerning the requirements for the products developed during this work package: the used materials, their transformation, processing and the experiments employed. it defined the principal materials to be used throughout the project for experimental trials and included furthermore a comprehensive state-of-the-art analysis of the filaments and fibres to be chosen and provided a structured basis for the research and development activities by identifying and validating the filaments and fibres suitable for the fabric production (wovens and nonwovens) in the subsequent work packages. the most suitable filaments, fibres and fibre blends as well as the most suitable fabric structures and their best production technologies were selected. at first, basic studies on pla (polylactic acid) fibres and filaments and requirements on their properties and temperature behaviour in the manufacturing process and during the life time cycle were of essential interest. textile substrates (wovens and nonwovens) for car interiors from renewable resource-based synthetic pla materials were identified which to be used as substitute for currently applied fibres or filaments. woven fabrics were produced from yarns made of 100 % pla filaments. different yarn constructions (for instance core-sheath) were investigated for different applications such as decorative fabrics. two main directions had to be taken into consideration for nonwoven structures: the first was to produce nonwovens of 100 % pla fibres to be applied as soft touch layer (as sound absorbing material for composite structures in door panels) and secondly to use thermoplastic pla fibres in blends with natural fibres (such as hemp) for moulded parts (doors panels). investigations in expected side-effects which might be occurring (such as odour, flammability or reduction in weight) have been also part of this wp. the final part mainly regarded to the materials selection and the processing, transformation and experimental techniques to be used. at the end of wp1, a decision on the fibres, filaments and textile structures that are finally applied were defined on the basis of all gathered requirements and information. these findings were needed for the correct execution of the project as well as for wp2 and wp3 both of them focused on the development of the biodegradable thermoplastic fibres and the pla compounding. finally, the structure for a demonstrator was developed and first sample demonstrators were produced in wp1. findings of wp1 have been also the basis for wp4 (optimization of biodegradable fabrics).   
  
work package 2 development of the base pla compound for textile production.  
in wp2 it is included all aspects related to the development of the new pla based biocompound: selection of the best additives, materials and its combinations, selection of the best equipment, processability of these different materials in order to obtain the final compound, optimization of this process and the machine parameters, etc. this pla based compound is the base material of the new biofibres comprising the prototype developed in the biofibrocar project.  
during the first period of the project, efforts were focused on the development and improvement of the best materials combinations (blends). first trials with selected materials were carried out and, even the thermal resistance was successfully increased, different problems were observed.   
in the second period different approaches were followed for the development of the compounds in order to achieve the desired properties. however, some of the were due to different problems, and new approaches not foreseen initially in the project, were included.  
  
work package 3 development/optimisation of biodegradable thermoplastic fibres  
  
workpackage 3 consists of establishing the parameters (temperature and velocity) that will be adjusted to suit requirements established in work package 1 for yarns to woven and nonwovens, employing diverse analytical techniques to achieve these requirements, to meet the requirements for yarns (for woven and nonwovens).   
  
the main objectives of the work package 3 âdevelopment/optimisation of biodegradable thermoplastic fibresâ were:  
  
â¢ the development of biodegradable synthetic textile fibres from different pla compounds using melt spinning.  
â¢ the manufacture of pla-based core-sheath fibres with improved abrasion resistance from the different nano compounds prepared in the previous stage.  
â¢ the functionalisation of different pla fibres, by the additivation of pla polymers with odour-absorbing particles or with improved fireproofing capability, to produce innovative automobile fibres.  
  
the above objectives were achieved during the first project period (m1-m12) and were continued and extended by the following activities in the second project period from m13-m30:  
  
â¢ the main objective is to develop new pla-based fibres chemically modified or blended with other biopolymers, with the aim of enhancing their thermal properties using a highly crystallised polymer to increase its vicat temperature (over 100âºc).  
â¢ fibre is a functionalisation with different additives to avoid undesirable odours from the fibre.  
  
after the different blends or compounds have been manufactured and analysed in the previous wp2, the compounds that are most appropriate to be spun into fibres, and that will offer the best possible results were identified. these compounds were developed into fibres (using a pilot extrusion plant). once this was achieved, the fibres were analysed mechanically and optically to establish comparisons between them and existing textile fibres (non-renewable origin).  
  
work package 4 development / optimisation of biodegradable fabrics  
pla-phb blends and stereocomplex pla were successfully spun into filaments and further developed into fabrics and nonwovens (wp3). the trials in the project biofibrocar for the development of woven and nonwoven prototypes from pla fibres have been successfully witin wp4.   
  
the prototypes have been manufactured with the parameters of the reference products in the automotive industry in consultation with the industry partners. the prototypes have been tested for their mechanical and functional properties and benchmarked against the reference products for requirements in the automotive industry.   
  
the mechanical performance of the stereocomplex pla has found to be superior to the reference polyester fabrics. the abrasion, pilling, light fastness and flammability are above the requirements of the automotive industry. therefore, the reference fabrics have a potential for application in the automotive industry as seat cover fabrics.  
furthermore, a demonstrator door panel has been developed with the nonwoven and woven fabric developed in this work package  
  
work package 5 environmental, economic and regulatory studies.  
wp5 comprises an exhaustive study concerning environmental aspects, economic analysis and regulatory issues of the products developed during the biofibrocar project.  
environmental study.  
the methodology selected in order to analyze the environmental impact of the new biodegradable fibers developed has been the lca (life-cycle assessment). this is a technique that takes into account all the stages of a productâs life from cradle to grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling).   
  
analysis of the new thermoplastics fibersâ recyclability.   
as recyclability is a very important property on plastic material, the regrinding tests carried out in this task have been oriented to study the reprocessability of industrial scrap. furthermore, this issue is very critical for pla because this material is highly sensible to degradation and loss of rheological properties.  
test have been performed in order to establish if the recycled material may be incorporated to some extent, without influencing negatively the properties of new materials. different experiments were carried out on developed biocompound and on 100% grinded scrap.  
samples obtained were characterized and results showed a small decrease in mfi and vicat temperature, as a consequence of thermal degradation suffered by the material during reprocessing. however, the difference is small and mfi and thermal resistance were still suitable for ems process and accomplish automotive applications requirements.  
  
evaluation of biodegradation of the full textile substrates in laboratory scale test.   
in order to verify the biodegradable condition of the new developments (compound/fibres/prototype), test samples were evaluated according to the standards en 13432:2000, specifically the iso 14855-1:2005 âdetermination of the ultimate aerobic biodegradability of plastic materials under controlled composting conditions â method by analysis of evolved carbon dioxide â part 1: general methodâ.  
two different samples were evaluated:  
- sample 1: carded nonwoven of cross-linked compound obtained during the first period of the project.  
- sample 2: carded nonwoven prototype made with final formulation selected.  
  
criterion: > 90% absolute or relative biodegradation.  
both samples showed biodegradation percentages > 90% under composting conditions after 80-85 days, so both of them are biodegradable.  
furthermore, as sample 1 contained zn in its composition, a zinc metal analysis has been done in order to check the amount of metal present in the formulation.  
economic analysis.  
in order to evaluate the economic viability of the prototype developed, a study of material and product costs has been done. only the final pla formulation selected has been assessed to make an estimation of the product cost.  
the evaluation has been carried out taking into account the price of the commercial components used for the elaboration of the different layers of the prototype and the processing cost data at pilot plant level. however, aspects like disposal and removal cost and market evolution have been taken into account. the results have been compared with reference material currently used for car interior components.  
regulatory analysis.  
since the new developments of biofibrocar project (fibres/door panel) have to fulfil the related ec directives for automotive components, a compilation of these directives has been collected and presented into a report. each partner and rtd has collaborated in this task in order to have represented the entire value chain of the products.  
european regulations (reach regulation), specific regulations for the development of car parts provided by validator partners, and end-of-life vehicles aspects have been taken into account.  
safety issues.  
in order to complete the regulatory analysis, definition of safety criteria has been carried out. all standards and legislation aspects related to the new fibres/prototype, like voc emissions or formaldehyde content, has been considered. all the information has been gathered in d5.16.  
  
work package 6 industrial scale up and product validation.  
  
in work package 6, we developed and produced the different prototypes using the textile fibres and fabrics developed in the previous work packages and taking into account the technical specifications required for this equipment. these prototypes have been tested and analysed according to the standards relevant to this kind of article.  
the main objectives of the work package 6 âindustrial scale up and product validationâ were:  
â¢ the transfer of the processes developed to an industrial scale.  
â¢ the development of the first industrial-scale prototypes.  
the activities planned in wp6 were subdivided into different tasks:  
  
prototype development  
in this task, all the partners were charge on the development, design and manufacture of different articles and products on an industrial scale, that served as prototypes and that possessed innovative functional characteristics for the car industry and in particular, for vehicle interiors.  
  
characterisation  
a battery of tests were performed on the prototypes installed in vehicles, to evaluate the prototype performance  
work package 7 training, dissemination and exploitation of results.  
  
dissemination of the project helps to increase the opportunities of exploitation of the foreground generated in biofibrocar project. the definition and implementation of an efficient dissemination strategy that will ensure the eu industry awareness of the project developments were one of the activities performed during the first period of the project. also a draft version of plan of the use and dissemination of the foreground and different activities were carried out by the different partners of the consortium.  
in this second period a final version of the pudf was drawn up. all dissemination activities have been compiled and included in it. the document provides a detailed overview of all dissemination activities carried out in the lifetime of the project. also gives a general view of the exploitable project results and related planned exploitation activities of the partners.  
  
different activities like training events and redaction of a best practices guideline have been carried out in order to make an effective transmission of the information obtained during the project. in order to ensure the efficient technology transfer of the biofibrocar project developments a set of training events have been imparted to train the technical staff of the smes. the idea was to transmit the information obtained during the project (materials, structures, processes) with these training activities. each rtd performer prepared a set of training materials (powerpoint/pdf presentations) based on the results achieved and the trials performed in the project.  
  
potential impact:  
the first concern of the sme participants within biofibrocar is that the project resulted in strengthening their own competitiveness and resulte in a growth in volume, turnover and profit margins based on the novel products that can make the difference in the economic environment.   
there are indeed good foresights that the envisioned products and processes will become a success.   
first of all, it must however be quoted that the project is not specificly aiming at a âreduced cost productâ if compared to standard bedding products. competing at such a level seems quite impossible for the european textile manufacturers, given the strong competition from developing countries. instead, biofibrocar, targets high added value products of high quality, which are healthy to use for consumers and which have a high eco-friendly aspect.   
these latter aspects, ecological and human safety concern are the main drivers for the project and were the basis for starting the project. the presence of potentially toxic products in current bedding materials is a major concern within the community and more and more end-users are asking for safe alternatives.  
the use of a new materials which are gaining a foothold in the textile industry in applications where recyclability is limited owing to the presence of plastic-mix materials and where biodegradability and composting may be important, without adversely affecting the productâs properties.   
  
the objectives achieved by using biodegradable materials in the car industry are summed up as follows:  
  
â¢ the development of more environmentally-friendly products and processes.  
â¢ the development of processes that allow the use of alternative raw materials to petroleum-based ones, with the consequent reduction in greenhouse gas emissions.  
â¢ the manufacture of fibres with similar properties to polyester-based ones.  
â¢ pla density is lower than that of pet so the total weight of the artefact is smaller.  
  
research has been focussed on the modification of pla-based polymer formulations for textile applications in the following areas:  
  
- the improvements of the abrasion resistant properties in fabrics designed for vehicle interiors.  
- the improvements of the fireproofing and fire behavioural properties in non-wovens used in side panels in vehicle interiors through the incorporation of different types of anti-corrosive additives and nanoparticles with enhanced effects.  
- increases in temperature resistance of existing pla fibres using reactive extrusion.  
- reductions in odours, whether by the inherent properties of the fibres themselves or by functionalising them to absorb internal odours generated inside the vehicle.  
- the development of pla-based bicomponents to improve technical aspects such as strength vs. abrasion, mechanical properties and even reductions.  
  
the dissemination activities of the project have been consistent with the originally planned dissemination activities of the project proposal. the partners, as depicted inbelow, have used an array of mediums and tools in order to successfully disseminate the project to the relevant audience. the presentation of prototypes and other relevant technology has been available for partners and has been promoted to customers and other stakeholders. in order to raise public awareness of the proposed technology, the partners have performed pre-marketing stimulation activities such as editorials, conference papers, sales, presentation in fairs and marketing contact with potential customers internationally, through the use of trade press, trade bodies and plant suppliers, approvals bodies, consumer groups and regulatory authorities. activities include technology demonstration events, major exhibitions, stimulation events, presentations and conference papers, databases and the distribution of project promotional material.  
dissemination activities were made through various communication channels; the main instruments and media that were used for dissemination purposes fall within the following areas:  
a) events (see section 2.2.1)  
events refer to both collaboration and dissemination and include participation in, or organisation of:  
â¢ presentation at conferences  
â¢ workshop for the key stakeholders  
â¢ exhibitions, trade fairs  
â¢ training events  
â¢ networking sessions  
â¢ specialised events  
b) publications (see section 2.2.2)  
publications refer to both electronic and printed media, including:  
â¢ press releases  
â¢ short articles published on the internet or in journals and relevant magazines  
â¢ newsletters and other information material produced by the partners  
â¢ papers published and presented in conferences  
c) electronic media (see section 2.2.3)  
electronic media is primarily concerned with the projectâs website and the services made available there:  
â¢ content published on the biofibrocar website  
â¢ content published on the partnersâ company website about the biofibrocar project  
2.2.1 events   
the project was noted with overall success in relation to the participation of the partners in events. a variety of different events took place such as conferences, participation in exhibitions and fairs as well as participation in seminars. the technology of the project has been presented thoroughly and throughout these events, with the partners aiming at maximizing the visibility of the project. the events helped to promote the project towards targeted audiences via personal fair stands and promotional material.   
in relation to external conferences, the partners have participated in world-renowned conferences such as: see table 1.  
specific mention must be made in relation to the type of audience each event was targeted, since the dissemination activities performed approached an array of interested parties, coming from different fields and areas of interest. universities and academic institutions, technology institutes and industrial partners are some examples of the type of audience the dissemination activities aimed at. specifically for industrial partner, it is notable to mention that events took place such as participation in conferences, fairs and exhibitions satisfying industry.  
as far as project meetings are concerned, the partners met three meetings, as prescribed within the project proposal. the first meeting (kick off meeting) took place in alcoy spain, in january 2013, where the partners had the opportunity to present their organizations, describe their involvement in the project and launch the definition of the user requirements with the active involvement of the end users. the second meeting (m6 meeting) took place in nijverdal, netherlands in july 2013. the third meeting took place in valencia (m12 meeting). the fourth took place in chemitz (m18 meeting). the fifth took place in aachen (m24) eventually, the final meeting will be held at aitex facilities in june. the partners had the opportunity to comment on the work progress and establish internal deadlines. dissemination and exploitation workshop was also established on this meeting and several telephone conferences between the partners served as a follow up to ensure that all aspects of dissemination and exploitation activities are carefully taken into consideration..   
2.2.2 publications   
publications, either in the form of press releases or as scientific papers with the intention of being published and/or in the process of being published, have played a significant role in the dissemination of the project. the project has been disseminated in various newspaper articles, both in hard copy and on the internet. many articles published concerned the distribution of the projectâs press release in notable magazines, scientific journals and industrial blogs.   
press releases were aimed primarily at the local audience, particularly professionals and industrial stakeholders. this medium has proved particularly useful since it has disseminated the project at large to a wide public which would not be easily identified via standardized methods of dissemination such as events and scientific conferences. all partners have maximized the potential for dissemination and visibility via the projectâs press release. as it can be depicted in table 1: list of dissemination activities, a variety of academic, online and popular journals have published the biofibrocar press release  
2.2.3 web sites  
the project website (http://biofibrocar.aitex.es/) acts as a dissemination platform with the aim to establish an efficient and effective dissemination and communication tool for the biofibrocar consortium for the duration of the project. the website construction consists of one of the main dissemination tools of the project, which will ensure the successful use of project results and non-confidential information to the widest possible audience (including the industrial and academic community). the website has a clear structure with two types of webpage navigation depending on the type of user i.e. visitor (public), consortium member or representative of the european commission (members area). the potentials for navigation, document uploading and website alterations differ for each type of user. the aim of the website is on one hand to inform general public about the biofibrocar project and on the other hand to constitute a tool to communicate and to exchange information on the project between partners. the technical management of the biofibrocar website belongs to the project coordinator, aitex. the project coordinator updates the website, inserts data and generally regulates the methodology for technically managing the website. technical management is implemented through the content management system and also includes the registration of the website addresses and regular renewal of the subscription as well as any necessary arrangements for the website hosting, including the 2 gb storage capacity in order to ensure that all necessary documents are properly stored either in the public documents area or in the members area.   
for the purpose of effectively disseminating the project, the following materials were produced:  
â¢ project logo: a project logo has been designed at the beginning of the project to be used in all dissemination material to enhance easy identification of the project among the members of the target groups. this logo can serve, as well, as product logo in the post-project phase (annex 1).   
â¢ project leaflet: a three-fold project brochure has been created; it describes the consortium partners and provides their main contact details as well as the general and technical objectives of the project. the brochure is user-friendly, compact and easy to understand (annex 2).  
during the first period of reporting a draft of the exploitable foreground was elaborated. at that moment, the exploitable foreground that the consortium foresaw was gathered in the pudf.  
  
list of websites:  
http://biofibrocar.aitex.es/

# SMARTBLIND

Project Acronym: SMARTBLIND

programme & topic: FP7-NMP EeB.NMP.2012-5

Most frequent returning words in objectives:

* ('smartblind', 20)
* ('project', 19)
* ('window', 14)
* ('system', 12)
* ('energy', 10)
* ('exploitation', 10)
* ('plan', 10)
* ('market', 10)
* ('meeting', 10)
* ('smart', 9)
* ('strategy', 9)
* ('seminar', 9)
* ('film', 8)
* ('consortium', 8)
* ('results', 7)
* ('textile', 6)
* ('connectors', 6)
* ('ditf', 6)
* ('architecture', 5)
* ('windows', 5)
* ('control', 5)
* ('dissemination', 5)
* ('technologies', 5)
* ('buildings', 5)

executive summary:  
the smartblind project aims to develop an energy efficient smart window. the window will include a hybrid film composed of an electrochromic film and a photovoltaic film printed onto a long-lasting flexible substrate. the realisation process will be implemented thanks to electrochromic and photovoltaic inks specifically formulated to be ink-jet printed.  
  
project context and objectives:  
the consortium aims to produce a hybrid flexible film and energy saving window (with single or multiple panes) that could enter the new build and renovation markets. to promote an autonomous system, the consortium brings together many disciplines (including polymer chemistry and physics, electronics, modelling, building engineering and architecture) coming from public and private research ecosystems.   
  
project results:  
the smartblind project aims at the development of an energy efficient smart window. the window includes a hybrid device composed of electrochromic film and photovoltaic films.   
  
the smartblind consortium has 4 main objectives:  
1. to reduce the weight by 50% when compared with glass windows, while offering transparency and flexibility.  
2. to improve the optical response time of windows while enabling the switching to larger panes.  
3. to integrate an electronic control system with an embedded power source.  
4. to guarantee a low-cost industrial solution adaptable to large and shaped surfaces.  
  
the main steps of the programme include:  
1. specifications (wp1).  
2. basic materials: substrate treatment, formulation of electrochromic and photovoltaic inks adapted for ink jet printing (wp2).  
3. printing process (wp3).  
4. simulation and building integration (wp4).  
5. mechanical tests, ageing and life cycle assessments (wp5).  
6. proof of concept (wp6).  
7. dissemination, exploitation (wp7).  
  
the project was officially launched on 1st september 2012. overall, the initial schedule has been respected from a technical point of view. some tasks were rather ahead of schedule and others slightly delayed, which has not been prejudicial for the project.   
  
an important point concerned the validation by the consortium of the specifications of the smartblind device. the device has been defined in detail considering possibilities and restrictions of the relevant technologies.   
  
during the whole program, a major emphasis was given on the basic ec and pv materials and up scaling of inkjet printed samples and resulting cells. the inkjet process allowed validating basic materials and inks that will be used for up scaling. in parallel, several characterization methods of inks and deposit layers have been used.   
the study of pv/ec repartition showed the need to precise the pv characteristics, and to know the acceptable surface ratio for the end user.   
  
regarding material layer superposition, a change in the position of the layers in the stack and the impact on the solar performances of the smartblind device has been studied.   
  
an electronic system, allowing switching the ec thanks to a pv panel, was designed, built and used.   
  
architects involved in the smartblind project highlighted primarily visual comfort before thermal comfort. simulations to achieve an acceptable value of glare and thermal comfort were done for several climates and several orientations during different seasons.   
several demonstrators were also built for new buildings, renovation buildings, and textile architecture. they show strong possibilities in textile architecture applications.   
  
in more details, first simulations to achieve an acceptable value of glare have been done for several climates and several orientations during different seasons.   
4 successive square meter glass window demonstrators were built in order to test the improvements proposed during the project. the tests to evaluate glare in real conditions showed great improvements brought by the smart window system. several demonstrators were also built for textile architecture and also show strong possibilities in this field of application.   
  
mechanical and ageing tests were implemented. for life cycle analyses-lca and recycling, a systematic and deepened approach was followed. first âa4 sizeâ prototypes of double-glazing windows including ec film or pv cells have been developed and tested: the optical and electro-optical methods of the windows and the assembling method were tested.  
  
the exploitation plan shows that the commercialisation of some elements of the system (and not only the full innovative system) can allow widening the target market by diversifying market segments. a start up is now foreseen on connectors and the electronic system.   
dissemination activities included the successful and inspiring symposium on âfiber-based solutions for energy and constructionâ at the ditf denkendorf (20-21 may 2015).   
  
overall, the smartblind project was a very active and dynamic project all along its course. debates took place and mitigation solutions were proposed when challenges were encountered. the smartblind project had to face many technical challenges, many of which were met and even exceeded, including the development of a start-up plan.   
  
potential impact:  
dissemination and internal training activities:   
several internal workshops have been organized in combination with the general assembly meeting m18, m24 and m30. a second exploitation strategy seminar was held during the general assembly meeting m24 and a seminar on the business model and plan took place during the general assembly meeting m36.  
a very interesting international smartblind workshop was organised during the conference on âfiber-based solutions for energy and constructionâ at ditf denkendorf (20-21 may 2015). the plan for use and dissemination of the foreground- pudf has been further updated.  
  
internal workshops - training:  
multi-disciplinary research and technologies are involved in the smartblind project. this generates an inevitable need in the consortium for individuals understanding the multi-disciplinary research field. at the start of the project a poll was launched to collect needs in the various fields.   
in total 14 workshops have been organised. the annual technological reports verbatum 12 and 24 give a detailed overview of the workshops held in the period m3 and m24.   
  
1. numerical modelling, energy and daylight simulation - part 1 (wp4)  
2. control strategy, use of platform bcvtb, simulation tools - part 2 (wp4)  
3. the design of smart window with electrochromic layer and the control system design of electrochromic layer (lodz)  
4. life cycle analyses (ditf-itv)  
5. artificial ageing - part 1 (leitat)   
6. artificial ageing - part 2 (ditf-itv)  
7. building integrated photovoltaics bipv integration conditions (oriented to the french case) (cea)  
8. basics on electrochromic devices (polymage)   
9. testing of transmission, reflection in vis, nir, mir of films (ditf-itv)  
10. colour measurement (ditf-itv))   
11. etfe material properties and their uses in architecture (iaso)  
12. basics on inkjet printing technology (ardeje)  
13. basis of energy efficiency in buildings and occupants comfort applied to windows (vub)  
14. pv materials and devices, characterization (leitat)   
   
international workshop:  
beside the internal trainings an international workshop was organised (ditf - vub) for a european relevant audience. the very interesting international smartblind workshop was organised during the symposium on âfiber-based solutions for energy and constructionâ at the ditf denkendorf (20-21 may 2015).   
at the symposium various new developments as well as knowledge based on experience were presented. on the second day almost 60 audience member listened to high-interesting lectures about energy management for buildings with textile solutions such as the polar bear pavilion presented by thomas stegmaier (ditf) or shading systems presented by renowned experts from the industry.   
afternoon lectures had concerned with flexible photovoltaics and with the topics related to the smartblind project. mr. sixou (polymage) introduced the smartblind project in a very interesting kind. pedro almeida (ffct) abducted into the fascinated world of liquid crystals. ulrike bolz (ditf) comment on the environmental aspects of the newly developed smartblind window construction. feike reitsma (iaso) impressed with large constructions of textile roofs and the possibility to integrate the smartblind shading system (see link for the presentations http://www.smartblind-project.eu/dissemination2)  
during the breaks and after the lectures there was the possibility to exchange information and knowledge with the speakers and the audience. creativity and a rich potential for new applications were in the air.   
  
exploitation:  
an exploitation plan has been developed and iteratively improved: several versions of the pudf have been discussed during the general assembly meetings. the final version has been discussed during the final general assembly meeting in valence.   
it showed that the commercialisation of some elements of the system (and not only the full innovative system) could allow widening the target market by diversifying market segments. this exploitation strategy could create more competitiveness, business and jobs than a strategy exclusively based on the full innovative system. several sub-results were obtained but the consortium chose to particularly push two of them: connectors and electronic devices, and to support the setup of a start-up proposed by a smartblind partner (more details are provided below). the advice of the invited advisory board also allowed to better focus on smartblind impacts and market strategy.   
  
during these 36 months 10 exploitable results have been detected. during the general assembly meeting in brussels (m30) two of them have been selected to enter the market. the partner lodz is preparing a start-up plan for both ers (er2: connectors; er6: electronic control devices). during the general assembly meeting in valence (m36) a final seminar was organised. the ec expert mr giovanni zazzerini, gave an introduction on business model and business plan. prior to this seminar the partner lodz together with the ec expert, polymage, fccco and vub formalised the "start-up" plan which has been further re-examined and completed during this seminar.   
  
the list of exploitable results was iteratively developed throughout the project, based on consortium debates and expert interventions (exploitation strategy seminars).  
â¢ exploitation strategy seminar 1 (m12): selection of 4 exploitable results.  
â¢ general assembly meeting (m18): selection of 2 extra exploitable results (4+2).  
â¢ exploitation strategy seminar 2 (m24): selection of 1 extra exploitable result (6 +1).  
â¢ general assembly meeting (m30): selection of 3 extra exploitable results (7+3).   
  
different types of exploitable results can be defined. these are new technologies or products, new combinations of existing technologies and know-how.  
  
some ers contain the full equipped "smart window" (er1) or the reduced version with an on-off switch and without connectors, solar cells and battery (er10). others consist in a set of components (products, technologies and know-how) with applications beyond the smart window (er2, er3, er4, er5, er6, er7, e8 and e9).   
â¢ er1: smart window - global solution  
â¢ er2: connectors  
â¢ er3: flexible film  
â¢ er4: modelling framework  
â¢ er5: flexible pv  
â¢ er6: electronic control devices  
â¢ er7: wood-cork frame  
â¢ er8: methodology/service towards standardised conditions  
â¢ er9: material characterisation method/training  
â¢ er10: smart window - reduced version without connectors, solar cells and battery, focus on the active film and on/off switch  
  
each er has its own background, foreground & exploitation interest that was well defined in agreement with the consortium. the time to be ready to go to the market is different for each er. during the general assembly meeting m30 it was decided that the ers which are the closest to the market should be selected first. so the decision was taken to target one er which will allow collecting specific and straight-to-the point information able to lead to market penetration. the "quick win" should be identified.  
  
as lodz participates to er2 and er6 and has personal contact points with textile companies it could be a successful strategy to investigate this market and opportunity to set-up a start-up.   
during the final m36 general assembly meeting a business model and plan seminar has been organised. prior to this seminar the partner lodz together with the ec expert (mr zazzerini), polymage, fccco and vub formalised its "start up" plan.   
  
list of websites:  
the public website www.smartblind-project.eu provides information on the smartblind project.   
it consists in different topics such as home; news; partners; other smart window projects; dissemination (brochures, presentations of the smartblind international workshop denkendorf, papers, abstracts, posters....); calendar.   
  
partners participated to events related to the smartblind project, such as the topics on energy efficient buildings. for some of these events the partners have prepared a poster, abstract or paper. papers have been also written to be included in scientific journals.  
  
name, title and organisation of the scientific representative of the project's coordinator:   
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# DemoShopInstantShoe

Project Acronym: DemoShopInstantShoe

programme & topic: FP7-SME SME-2013-3

Most frequent returning words in objectives:

* ('shape', 44)
* ('footwear', 43)
* ('shoe', 38)
* ('memory', 34)
* ('project', 31)
* ('system', 31)
* ('process', 25)
* ('foot', 21)
* ('shoes', 21)
* ('order', 20)
* ('service', 18)
* ('personalization', 18)
* ('instantshoe', 15)
* ('tests', 15)
* ('manufacturing', 13)
* ('results', 13)
* ('shop', 12)
* ('shops', 12)
* ('textile', 11)
* ('production', 11)
* ('feet', 10)
* ('calzamedi', 10)
* ('validation', 10)
* ('prototypes', 10)

executive summary:  
feet diseases represent an important social problem, being the female population who principally suffer from it. the hallux valgus is the most frequent feet deformation affecting one of every five women at adult age. this pathology, together with other deformations of the front part of the foot, are in most cases caused by a continued use of inadequate footwear, providing a poor fitting between the foot and the footwear.   
  
the trends marking the aesthetics and fashion of the female footwear compels to realize a more precisely fitting to guarantee the comfort and functionality of this product. but the differences in morphometry of the human foot makes it very difficult to provide an adequate fitting to every user in a personalized way and causes that, especially in the case of women, the footwear becomes uncomfortable and unhealthy.  
  
in this context, the demoshopinstnatshoe project was created thanks to the funding of the vii framework programme of the european commission. its main objective was to develop a high-end female footwear being novel, ergonomic and personalized. therefore, this initiative has generated new footwear upper materials based on composites including a shape memory alloy, creating an innovative service of shoe personalization in-store.  
  
the process of the shoe customizable service, commercially called as instantshoe, needs only a few steps: the client first chooses a shoe model which she likes among the customizable collection in the shop. the dimensions of the clientâs feet are taken in few seconds in the store thanks to a low cost and easy to use foot scanner (commercially called âdomescanâ that generates the foot geometry in 3d). then, by means of an automatic shaping system, the upper part of the selected shoes will be modified in order to adapt the footwear to the client's foot geometry. the upper part of the shoes includes a specific shape memory composite, which allows keeping the given shape: the client can verify the fitting and decide if she buys the footwear, or not. if the footwear is rejected, a treatment in the customization box helps the footwear to recover its initial shape: it is heated to a certain temperature. this whole shaping/recovery process can be performed several times on the same shoe.  
  
the major innovation is that a client with light foot disease has a wide choice and can try the models in a shop, with possibility of buying the adapted shoes, or not: in this case the recover allows the shop assistant to reshape the model and keep it in stock. this is an advantage also for retail shops, where a new range of customizable shoes can be offered without incidence on the stocks level.  
  
the demoshopinstantshoe project finished on april 2015. the development of the shop tool, the shape memory composite and its manufacturing industrialization has been already completed, enabling the footwear personalization service at retail shops. users will benefit from the new customization service by the beginning of 2016, when instanshoe will start its commercialization in the worldwide market. for further information, please access the project website (www.instantshoe.com) or contact josã© joaquã­n chico (calzamedi@calzamedi.com) from calzamedi, company coordinator of the project and responsible for the instantshoe personalization service.  
  
project context and objectives:  
the demoshopinstantshoe (demosis) project is a direct follow on from the very successful shopinstantshoe fp7-sme-2008-1 project, which came to promising conclusions in february 2012. this project has been funded by the european commission through the vii framework programme in order to develop an aesthetic, innovative, ergonomic, comfortable and customized women footwear, as well as to industrialize its manufacturing process to be ready for its commercialization. for that purpose, a new material based on textile composites that will include shape memory alloys will be used. this new footwear concept will improve the comfort of customers especially of those women who suffer foot pathologies that appear after a long use of inadequate footwear.  
  
in this project, calzamedi has set up a new service of women footwear personalization on retail shops called âinstantshoeâ. for that, clientâs feet will be automatically scanned in store to gather its 3d geometry thanks to the foot measuring system called âdomescanâ. these dimensions will be used for deforming the footwearâs upper based on a shape memory composite using a specific shaping system. the shape memory properties of the footwearâs upper will allow the shoe to recover its original shape after being warmed if the customer rejects to buy it once the shoe has been personalized.  
  
the most outstanding benefits of this innovative product-service are:  
  
to consumers:  
-fitting customization based on individual feet measures.  
-increase in footwear comfort perceived by consumers that suffer from some foot pathologies.  
-reasonable price for an individual premium product compared with tailor-made and custom manufactured.  
-customization performed during the same buying session allowing the user to try out the product and wear it just after the purchase.  
-chance of changing their mind after personalization and decide not to acquire the personalized shoe.  
  
to retail shops:  
-high reduction in the time and cost required to manufacture customized footwear.  
-compatible with footwear designers for making fashionable and comfortable footwear collections.  
-reduction of stock of shoes at retail shops, since shoes with different wide are not required.  
-recoverability of conformed shoes, avoiding extra costs related to inaccurate footwear customization or non-sold products.  
  
the project ended on april 2015. the developed technology of the shoe personalization service was validated being ready to be commercialized directly on retail shops under the brand of âinstantshoeâ. six european partners had taken part in its development: two from spain (calzamedi who was the general coordinator of the project, and biomechanics institute of valencia who played the role of technical coordinator); two from france (texinov and nimesis, experts in textile knitting and shape memory alloys respectively), one shoe manufacturer and distributor from switzerland (technoboots), and one chain of orthopaedics stores in portugal (ortopedias twins).  
  
project results:  
project results are the following ones:  
1) shape memory alloy  
2) shape memory textile  
3) shape memory composite  
4) shape memory footwear collection  
5) foot measuring system  
6) shoe shaping system  
7) software  
in order to achieve these results, the work plan of the project has been followed. the technical activities that have been done by the partners of the project are summarized below.  
  
the work started in wp1 by determining the specifications of the product-service. these specifications have been translated into design requirement for all the components that have been developed in the project (shape memory alloy, shape memory textile, shape memory composite, shape memory footwear, measurement system, shaping system, heating system and software). this information was the guideline for the development of the different components in an efficient way.  
  
the objective of wp2 was to refine the manufacturing process of the shape memory textile, composite and footwear. first of all, texinov and nimesis defined the final technical data specifications of nitinol wires, defining the methods for testing the wires and the conditions of approval of new batches. secondly, texinov optimized the knitting process and adapted all required machines and elements (transformation of big spools of nitinol into small ones for an automated knitting process, adaptation of the knitting machine in order to reduce friction of the nitinol wires and thus avoiding any modification of the metallurgical state of the wires, and development of a special warp creel to enable the proper unrolling of sma bobbins without giving additional torsion to the wires). the adapted installations have been used for validating the production of shape memory textile at industrial scale.   
  
continuing with wp2, the manufacturing process of the shape memory composite at industrial scale was set up. the automatic gluing process of the nitinol textile with the upper material and internal lining has been optimized. different gluing suppliers and technologies have been explored before finding the one that best fits the specific properties of the shape memory textile. the gluing process is finally done by a french subcontractor enrolled in the instantshoe supply chain thanks to texinov. the optimization process consisted in defining the adequate gluing material, conducting industrial tests to define the most suitable process and adjust the parameters to achieve the final product. the industrial manufacturing method will finally be done thanks to a flat belt calender using glue under the form of a web supplied on roll. this provides an industrial way of manufacturing the shape memory composite with the required thermo-mechanical properties and de-lamination resistance, with the adequate aesthetics and comfort, and with the necessary production capacity in order to fit the quantities defined by the commercialization plan. the industrialization process has been done in parallel to the optimization of the shape memory composite, thus they were highly dependent.  
  
for finalizing with wp2, the manufacturing process of the shape memory footwear has been industrialized. two production runs were conducted during the project. the 1st one consisted of 45 pairs and was produced for laboratory tests and validation at ibvâs laboratory. during the 2nd production run, 40 pairs were produced for the validation at retail shops, 20 pairs for each retailer (technoboots in switzerland and ortotwins in portugal). after the 1st production run, all manufacturing steps were reviewed and several improvements were made in the shoe production which were implemented for the second production run. especially, the cutting process and the toe-puff were improved and adapted to the special properties of the shape memory composite.  
  
the shape memory textile, composite and footwear have been optimized in wp3 in order to achieve the desired thermomechanical behaviour. explained in a simply way, the shape memory footwear has to be deformed in the desired level, keep its deformed shape at room temperature, and recover its original shape in case it is heated over a specific temperature. for this purpose, a laboratory-scale thermomechanical test has been defined and realized. a complete testing plan including all selected materials, configurations and conditions has been conducted. after these tests, some initial materials were discarded and the final choice for upper material and lining has been done. next, the optimal parameters have been found (diameter, spacing and wavy pattern inside the textile of nitinol wires, thermal treatment, glue configuration, etc.). after manufacturing and testing several samples, three composites with different configurations were pre-selected. calzamedi prepared some shoe prototypes with them (composite a, b & c), and ibv tested their thermomechanical behaviour with the shaping system developed in wp4.  
  
the final composite configuration was decided after analysing together all the information from texinovâs thermomechanical tests on flat samples, ibvâs thermomechanical tests of shoe prototypes, and ibvâs user perception tests done in wp5. there were only some few differences on the thermomechanical behaviour of composites. nevertheless, composite b was the one most preferred by users after wearing the shoe prototypes. furthermore, the manufacturing process of composite b is easier, faster and cheaper (it does not require thermofixation process). consequently, composite b was selected as the final composite configuration that will be used for the instantshoe personalization service.  
  
some more tasks were performed before finishing wp3. on the one side, some shoe prototypes were sent to texinovâs laboratory and its upper material cut to evaluate the behaviour of the smc after suffering the shoe manufacturing process. the conclusion was that the smc can withstand the manufacturing process without significant changes in its behaviour. on the other side, some flexion tests were performed by nimesis on smc samples based on norm en 13512 in order to assure the flex resistance of the composite along the time. next, further tests were performed with both flat samples and footwear prototypes in order to evaluate the shaping properties of the composite along different heating cycles. the final configuration maintains it original shape memory properties for at least 10 recovery cycles. finally, calzamedi has designed the footwear collection in collaboration with ortotwins and technoboots as experts in selling orthopedic shoes. the collection is based on eight different models. four designs were combined in two lines: âheel lineâ (made with a narrow and aesthetic sole), and âflat lineâ (made with a wide and more stable sole). several shoe prototypes of different models were manufactured in sizes 37, 38 and 39 for the validation tests performed in wp5.  
  
wp4 aimed to generate the shop tool that is the device that will allow personalizing the shape memory footwear to the clientâs feet geometry. first, the technology to be used in the measurement system has been selected. the system is based on optical technology including no moving elements or carriages. this technology generates a foot scanner that is inexpensive, light, small, easily transportable, with components that require low maintenance, and intuitive to be operated by shop assistances. afterwards, a pair of different scanners prototypes has been performed. they were useful to prove the viability of the system and to optimize different components of the scanner. after that, the final prototype has been designed, manufactured, assembled and tested. the main improvements included the implementation of the final aesthetics, a reduction of its volume, the possibility to make it removable, the incorporation of bluetooth connection with the pc, the compatibility with a tablet running in windows 8, the programming of the final algorithms and control software, and the industrialization of its manufacture (defining every component, materials, production step, supplier, and production cost). after the development of the final prototype, three units of the measuring system were prepared for the validation tests of wp5. finally, ibv performed a study in order to determine the accuracy of the foot scanner. mean error of the foot scanner is less than 1 mm, and percentile 50 is 0.77 mm. that means that 50% of the area of the foot has an error lower than this value. furthermore, highest errors are located below the ankle and in the inter-toes area. these areas are not of interest for the instantshoe application, so the measuring system developed for the project (commercially named as domescan) has a good accuracy for its purpose.  
  
relating the shaping system, various initial prototypes were designed, tested and evolved. based on the testing results, one of them was selected for further evolution. on the one hand, the last was completely redesigned in order to adapt the position and the form of the extruders following the recommendations of ibv. the most important dimensions of the position, geometries and displacement of all extruders of the shaping system were calculated by ibv from its foot anthropometric database. in addition, ibv performed a study of how many mechanisms were needed in order to adjust all the range of shoe sizes including several possible combinations. after review with calzamedi the available room inside the last for hosting the needed movement level, it was decided to select 3 mechanisms to cover all the sizes range (mechanism 1: sizes 35 & 36; mechanism 2: sizes 37, 38 & 39; and mechanism 3: sizes 40, 41 & 42). on the other hand, a new anchoring system was incorporated allowing the exchange of the lasts depending on the needed size and the electronics was designed for its industrial production. all this was included in a tailor-made square box in order to introduce the scanner, a complete set of lasts and the motors for lasts adjustment. in addition, the recovery system was created which consists of a hot air system projected to the area to be recovered. in order to reach the necessary temperature, a casing was developed. to create the program, the dll were connected and it was tested to check that all the process from the scanning, last adjustment until the recovery works correctly. the software was created in english language, including translation to spanish, german and portuguese. after the validation tests by ibv with the prototype, some improvements and corrections were performed, creating thus the final version of the shop tool: the square box was improved by reducing 31% its volume and 29% its weight; the material of the last case was changed in order to better support the temperature reached in the recovery system; the internal anchors were reinforced; the initial and final points of transmission system were blocked to prevent breakage of wire transmitters; the casing of the recovery system was redesigned in order to better maintain the heat in the deformation area; and finally, a program of updates was created allowing the end user to have the latest version of the software in a simple way.  
  
in wp5 several tests have been done on shoe prototypes in order to validate the instantshoe product-service. first of all, some basic functional tests have been performed in order to assure a proper weight, flexibility and friction properties of the shoes. secondly, a flexion fatigue test on completed shoes simulating the real flexion produced during walking has been done by ibv in order to complement the ones realized by nimesis on flat composite samples. results were very satisfactory thus no damage was found assuring in this way the proper resistance of the shoe. next, the performance of the shaping system was checked. the position, dimension and movement level of the extruders were checked and compared with the theoretical ones. the heating process was also set up for a proper recovery of the shoeâs original shape. the temperature inside and outside the shoe was measured during the heating process on different areas of the forefoot. results were analysed and the design of the hot air tube was tuned up. final results on recovery tests demonstrated that 5 min of heating was enough for recovering the original shape of the shape memory footwear. in addition, a set of tests were performed to find the optimal shoe shaping process that maximizes the deformation level of shoes and minimizes the time spent to personalize the footwear. specifically, three shaping procedures were checked: a) deform the shoe at room temperature; b) deform the shoe while it is warm and let it cool down outside the shaping system; and c) deform the shoe while it is warm and let it cool down inside the shaping system. all shoes recovered completely their original shape independently on the shoe deformation method. nevertheless, the last shaping methodology is the one with higher residual deformation, and thus, the one that shows a better mechanical behaviour. therefore, shaping procedure c) was selected to be implemented in the commercial version of the shop tool.  
  
besides, a pair of validations with users was performed in wp5. the first study was done at ibvâs laboratory. users with slight and mild forefoot deformations tested one of the shoe models with different composite configurations, following the footwear personalization process. foot dimensions were determined using the measuring system, and by help of the shaping system and its software, prototypes of shape memory footwear were deformed. footwear dimensions were determined before and after its shape adaptation, and subjective opinions were gathered by questionnaires. users wore the footwear in 2 conditions: short-term (20 min of use) and long-term use (2 weeks of use). after analysing the information of the short-term test, it was decided to use composite b as the one to be used for the long-term test as well as for the final product. the results obtained during the validation with users at ibvâs laboratory after the long-term test were positive. after its analysis, some minor aspects of the shoe design were improved for the further validation at retail shops. anyway, the shoes were considered as very comfortable.  
  
after the validation at ibvâs laboratory, technoboots and ortotwins performed the validation at retail shops with real clients in switzerland and portugal respectively. the followed testing procedure was similar to the previous trials with users at ibv. first of all, a clinical foot evaluation was performed by a footcare specialist. afterwards, a pair of the selected shoe model was customized using the shop tool based on the patientâs feet geometry. finally, patients wore the shoes at store, and during at least one week at home, fulfilling some perception questionnaires. feedback of the whole personalization process was gathered from clients, but also from retail shop assistances. relating basic functionality aspects, the shoes provided enough grip, impact absorption and heel stability. furthermore, they were considered as very flexible and light-weighting. analysing the level of comfort perceived by users that participated on the validation at retail shops on both countries, shoes can be considered as comfortable. furthermore, users were very interested in a shoe personalization service at retail shops such as the one of instantshoe, being willing to wait at least half an hour for the shoe adaptation and to pay more for a pair of customized shoes in comparison to standard ones.  
  
potential impact:  
feet diseases represent an important social problem, being the female population who principally suffer from it. the hallux valgus is the most frequent feet deformation affecting one of every five women at adult age. this pathology, together with other deformations of the front part of the foot, are in most cases caused by a continued use of inadequate footwear, providing a poor fitting between the foot and the footwear.   
  
the trends marking the aesthetics and fashion of the female footwear compels to realize a more precisely fitting to guarantee the comfort and functionality of this product. but the differences in morphometry of the human foot makes it very difficult to provide an adequate fitting to every user in a personalized way and causes that, especially in the case of women, the footwear becomes uncomfortable and unhealthy.  
  
besides, european shoe industry needs to innovate for continuing being competitive: that is why instantshoe is the project that fits the best in the comfort shoe market. in this context, the european shoe manufacturers and distributors can offer to the clients a differentiation in terms of individual fitting and personalization, both immediate and cost-effective. for that purpose, the shoe industry needs to identify, assimilate and exploit the new technologies to continue being competitive, as well as developing new concepts, aiming at applications of added value in areas as materials and services.  
  
in this context, the demoshopinstnatshoe project was created. its main objective was to develop a high-end female footwear being novel, ergonomic and personalized. therefore, this initiative has generated new footwear upper materials based on composites including a shape memory alloy, creating an innovative service of shoe personalization in-store.  
  
during the project, the development of the shop tool, the shape memory footwear and its manufacturing industrialization has been completed and validated. furthermore, other kind of activities related to the exploitation and dissemination of the results have been done:  
  
a) ipr issues have been dealt, defining specific protection strategies for the different results.  
b) a marketing and communication strategy has been also established, differentiating between a business to business (btob) strategy, and the business to customer (btoc) one. the agreed marketing strategy is a mixture of both emotional and rational aspects.  
c) the corporative brand âinstantshoeâ has been created and will represent the shoe personalization service during the commercialization phase.  
d) a commercialization plan has been proposed, aiming to generate a worldwide market for the instantshoe service.  
e) a pricing strategy has been elaborated, starting from performing a production cost evaluation of the different components and devices in order to establish the final selling price of both the shape memory footwear and the shop tool.  
f) a business plan has been detailed, defining a sales estimation of shoes and retail shops that will commercialize the instantshoe service.  
g) the economic impact of every partner of the consortium has been evaluated together with the initial investment performed. results demonstrate the economic feasibility of the instantshoe personalization system.  
  
on the other hand, several actions have been performed for disseminating the demoshopinstantshoe project along the time. the logo and the website of the project (www.instantshoe.com) were prepared at the first months. a flyer and poster containing basic information of the new personalization system has been prepared in english, spanish, french, german and portuguese versions. companies of the consortium have showed the poster and distributed flyers in eight fairs during the development of the project. articles have been published in magazines such as âdevicemedâ, âquoâ, âmuy interesanteâ and âbiomecanicamenteâ.  
  
furthermore, a final event was organized at the end of the project in order to show the instantshoe personalization service. a press note about the project results was prepared previously and sent to several press media. local authorities and the interested press media attended to the final event. it consisted on a live show of the shoe personalization service of instantshoe, explaining every step of the process and its functioning. the feet of a model were scanned with the measuring system, and a pair of shoes with shape memory effect was personalized to her using the shaping system. the functioning of the shape memory textile and the customized shoes were shown to the audience. finally, the shoes were recovered to its original shape. several newspapers, websites and magazines published various articles, interviews and reports about the projectâs official ending and its results. a total of 22 impacts on different press media have been registered including information of the project. the spanish national tv channel âtelecincoâ recorded a report after the final event (https://www.youtube.com/watch?v=-fj203klrag). it was broadcasted on tv the day after in the morning news space at spanish national level.  
  
to conclude, the demoshopinstantshoe project finished on april 2015. the instantshoe service has been set up and validated. clients will benefit from the new customization service by the beginning of 2016, when instanshoe starts its commercialization in the worldwide market. for further information, please access the project website (www.instantshoe.com) or contact josã© joaquã­n chico (calzamedi@calzamedi.com) from calzamedi, company coordinator of the project and responsible for the instantshoe personalization service.  
  
list of websites:  
information about shopinstantshoe project is available at its public website: www.instantshoe.com. for any suggestion, please contact josã© joaquã­n chico (jjchico@calzamedi.com) from calzamedi.

# AChSo

Project Acronym: AChSo

programme & topic: FP7-JTI JTI-CS-2012-1-ECO-01-052

Most frequent returning words in objectives:

* ('preform', 51)
* ('process', 47)
* ('production', 42)
* ('line', 36)
* ('resin', 36)
* ('textile', 32)
* ('unit', 30)
* ('layers', 27)
* ('chemical', 25)
* ('injector', 22)
* ('time', 19)
* ('technology', 18)
* ('rollers', 17)
* ('injection', 17)
* ('device', 16)
* ('speed', 16)
* ('preforms', 16)
* ('design', 15)
* ('processes', 15)
* ('shape', 14)
* ('fibre', 14)
* ('tapes', 14)
* ('amount', 13)
* ('viscosity', 13)

executive summary:  
the chemical stitching und continuous preforming technologies had been developed independently and needed to be combined into an integrated process. this necessitated extensive design work and the manufacture and assembly of a new preform production line.  
the forming, stitching and curing units though had to be designed specifically for the final product(s) to be produced on the device. the first step in the production is the cross section forming. to learn more about the possibilities of the cross sectional several concepts for draping mechanisms were considered and tested in the form of lab scale prototype devices (d2-2) to help choose the best technology for the final design. the two possibilities that exist are preforming with a solid forming tool and preforming using a set of rollers. for the preform geometry with l sections and flat doublers, the forming method of the roller based technique was chosen for best quality.  
  
the rollers gradually change the flat textile into the l shape. after the forming and before the stabilisation of the stitching the shape is kept by a snug fitting solid tool, that is able to guide the preform but is too narrow for the flat doubler. the doubler preform is transported up and over the roller section of the preforming unit and passes the section thus without any clearance issued.   
the chemical stitching was also advanced. first, concepts were developed how multiple stitching points can be set simultaneously. also it was considered, what kind of injectors could be used in the final design. the simple injector used before was replaced with one that can deliver the controlled resin amounts necessary for the industrial application of this technology, this new injector was tested in a lab scale prototype of the stitching unit to determine the best process parameters concerning adhesive amount, curing time, curing temperature etc. in the detailed design of the production line the stitching unit was designed to reflect the production of the two different profile geometries.   
the manufacturing and assembly of the new preforming line was completed on time. the integration of the resin injectors was the more challenging task. the injectors must move at the same speed than the textile layers through the preforming device. at the same time, they must also move up and down. these individual movements must be synchronised for the process to function. other parameters like the resin viscosity, which depends on the amount of curing agent, also influence the setting of these movements. the viscosity influences the injection time, which is limited by the maximum pressure the injectors can achieve. the amount of curing agent curing agent must be set according to the speed of the textile, because this determines the amount of time the resin points will remain in the hot curing zone.  
after lengthy optimisation of these parameters and the chemical stitching device, a functioning, stable and high quality process was achieved. due to the automated and continuous manner of the preform production line, even a 24 hour usage of the device is viable with minimal downtime. under these conditions, a production rate of 1000 m of stacked, shaped, stabilised, cut and infusion ready preforms is not unrealistic.  
  
project context and objectives:  
lightweight requirements have always accelerated innovation in the aviation industry and have found their current highpoint in the extensive application of composite materials in the airbus a350 and boeing 787. lightweight structures help save fuel and co2 making transport by aircraft at the same time more economical and more ecological. increasingly though, in order to further european competitiveness, cost requirements also play a large role in the airplane design. this leads to two developments: firstly the use of dry fibre textiles and liquid composite moulding (lcm) technology instead of prepreg processes; and secondly the need for highly automated processes. these goals are somewhat in contrast to each other, since todayâs prepreg processes are to a large degree automated while dry fibre textiles are more difficult to handle in automated processes. from this arises the need to develop fully automated dry fibre preform processes.  
fully automated preform processes are especially needed for the production of small parts which occur in high numbers. to mind come profiles such as stringers, frames and spars for which several kilometres of profile preforms need to be produced for each aircraft, resulting in a huge number of necessary preforms is one considers the future rates of aircraft production of more than 40 aircraft per months for single aisle aircraft. such profile preforms are well fitted for continuous automated processes. todayâs state of the art continuous preforming technologies such as pultrusion however, do not offer the necessary quality and process control for aerospace applications. new preform processes must be developed to accommodate the demand for a fully automated preforming process for the production of 3d-shaped dry fibre profiles for the aerospace industry.  
  
todayâs preforming technologies are largely manual, thus increasing the costs of liquid composite moulding (lcm) technologies such as resin transfer moulding (rtm). systems that can drape 3d profiles automatically and continuously, such as the one developed by fibre, have just left the development stage but are in need of further development to in-crease productivity and quality. the projectâs objective is to develop a fully automated dry fibre preform process for 3d-shaped composite profiles that uses the energy efficient chemical stitching technology.  
the chemical stitching (cs) technology offers a way to reduce the lead time by replacing the time consuming binder application with localised adhesives application. for the application, needles are be used which inject either a thermoplastic (hot melt) or thermoset (microwave curing) adhesive between the layers. this will also improve permeability and thus the quality of the finished part. furthermore is the chemical stitching technology more energy efficient because melting or curing of the adhesive is restricted to minimal areas and volumes.   
in previous investigations within cleansky ecodesign project, the feasibility of chemical stitching approach was demonstrated by fraunhofer gesellschaft with ultraviolet (uv) and microwave (mw) curing adhesive.   
the process starts with positioning of the adhesive application head on the textile structure which should be fixed. at the same time the textile structure is fixed mechanically. after-wards thin injection needles are driven into the textile structure to implicate minimal amount of the chosen binder adhesive between the layers. following step is to cure the implemented adhesive.   
  
the local adhesive implementation via chemical stitching approach shows a lot of advantages compared to areal bindering. these advantages are:  
â¢ two times faster vari infiltration of the preform (nearly the same as unbindered) due to a better permeability   
â¢ same peeling forces by using 3 times lower amount of binder   
â¢ same preform compressibility as a nonbindered textile structure.  
â¢ higher peeling strength by using same amount of binder,  
â¢ furthermore is the chemical stitching technology more energy efficient because melting or curing of the adhesive is restricted to minimal areas and volumes.  
  
the cs technology is today only available as a lab scale test bench based on a gantry device. in this project the cs technology shall be advanced to level where it can function in a relevant industrial environment alongside other proven technologies. for this the process must move away from a single injector gantry device to a process that can stitch in parallel with very high speeds to match the line speed of the preforming process. in the lab device, the fabric is fixated with a vertical stamp. in the continuous process this will have to be removed to make the continuous movement of the fabric possible. this removal is easily implementable, because in the continuous preforming device, the fabrics are fixated in any case by the rollers that form and transport the fabric.  
with the technology previously developed by fibre it is possible to produce full scale aerospace preform profiles of different geometries including complex lcf-frames, sidestepping any problems that will arise from up scaling. up scaling is extremely difficult for fabric related processes because the weave cannot be scaled up or down without significantly changing the drapeability of the fabric. the prototype uses sets of rollers to form the flat fabric into the desired shape. the line speed can reach up to 10 m/min. dependent on the profile geometry will the fabric layers fixed to each other before or after the forming sequence, using powdered binder across the entire area of the preform. the prototype includes devices for producing curved preforms, automatic cutting, and automatic removal of the preforms at the end.   
this 3-d preforming technology can be combined with the chemical stitching technology to create an automated solution for a continuous, energy efficient process for the manufacturing of 3-d shaped composite dry fibre profiles. this requires developing the chemical stitching technology further from the current lab-scale batch process to an industrial scale that can function continuously. the stitching speed also has to be synchronised with the speed of the preforming process. in order to apply the adhesive in parallel to the preforming process an array of needles will inject the adhesive at different places simultaneously. because the cycle of filling the injector, positioning it, injecting the adhesive, and retracting the injector is too time consuming, several injectors have to be arranged in sequence. to match the chemical stitching speed to the preforming speed several sets of needles need to be used. another solution would be to move the needles horizontally to match the velocity of the fabric. the cs device is arranged past the preforming device to fix the fabric in its new shape.  
in a second phase after the current project, it can be matched with a continuous curing technology. the basic technology of the continuous curing is has been developed also at fibre, but to bring it to industrial maturity further development is needed. this applies specifically to profile geometries that vary along their length e.g. due to ramps, steps or joggles.   
this project's objective was the development of a preforming process that can produce reinforcement profiles preforms that are stabilised by chemical stitching. chemical stitching is a technology to fixate the textile layers using very small amounts of locally applied liquid adhesive. the industry standard way is to use powdered binder adhesive across the entire textile surface. replacing this with the minimum amount of adhesives used in chemical stitching improves infusion characteristics and laminate quality.  
the process is fully automated and was validated by producing spar preforms, of high enough quality to integrate them into the cs eda wp2 demonstrator a4 âaileron of do 228â.  
  
project results:  
concepts for draping mechanisms   
to study the process of continuously preforming of a flat textile tape into a three-dimensional profile geometry a continuous preforming prototype was developed and build. the prototype works like the later to be build final preforming device but allows more freedom to change the preforming technique used. a proposed setup uses a solid metal forming tool, to form the flat textile tape on the right into a three-dimensional profile. this technique is investigated as an easier, less complicated way to shape the textile than the previously used technique with rollers. the continuous preforming prototype can, nonetheless, also be used with rollers in which the roller positions and attitudes can be changed in a greater degree than a final version that will be optimised towards an ideal shape.  
concepts for stitching design  
for the stitching injector a two-component injector head will be used. it can be filled with the two components of an adhesive which will be mixed at the moment of injection. this way no pre-mixed adhesives have to be used. pre-mixed adhesives always have a limited use time, because the adhesive is slowly curing inside the adhesive reservoir. this can be avoided with the two-component head. it is also capable of injecting the highly viscous adhesive in a very short time. high viscosity is needed to achieve a localised disposition of the adhesive. if the viscosity is chosen too low it will be soaked up by the surrounding fibres instead of staying at the injection point. high viscosity on the other hand is detrimental to a short injection time. the chosen injector type is able to achieve a short injection even at the high viscosity that is needed. before the final choice is made, the injector head will be tested with the actual adhesive to be used in the project.  
to further increase the production speed, a multi-needle setup will be used. the injector head is going to be equipped with multiple needles. this way, several stitching points can be set at the same time and no movement of the injector head in the transversal y-axis is required.  
selection of technology for draping (rollers) and stitching (injector specified)  
even though a new draping mechanism using a solid tool was studied with a lab scale device, the known technique of gradually forming the flat textile into the desired shape. the rollers give better control of the preform especially considering the switch to l-profiles and even flat preforms (if they can be called as such). a c-preform is stabilised when it runs through the preforming device because its two flanges grip around the positive toll and so it cannot move left or right. an l-profile is not stabilised as such. therefore it was decided revert back to the roller based setup planned in the beginning.  
for the stitching unit an injector, that fulfilled the criteria for industrial use was selected. up to this point, the chemical stitching used an injector that could only be used for very slow stitching of the textile, and would not be acceptable in an industrial application. the chosen injector head is the viscotec viscoduo v- 4/4. it is capable of placing very small amounts of resin at a speed that is usable in the integrated process. this is important because exact control over the deposited amounts of resin is necessary to produce preforms that are both stable but also have only a minimal amount of stitching resin in them. a too low amount of deposited resin in a stitching point would lower the preform stability necessary for subsequent handling and injection steps. a too high amount of resin would block the bath of injection resin in this area and would therefore be detrimental to preform permeability and also laminate mechanical properties.  
final design of integrated preforming production line achieved (ms2)  
the most significant achievement is the final design for the integrated preform production line. it combines two very innovative technologies. the design also incorporates all the knowledge previously gained in this project. the tasks that preceded the final design advanced the preforming and stitching technology so that it could be integrated into an industrially usable machine.  
an overview of the complete preform production line is given in fig 6, in which the subunits that are combined to form and fixate the preform are shown. the subunits demonstrate the modularized, flexible design of the preforming production line. to the right is the material store unit where the different textile tapes for the different geometries are stored as coils. to the far left is the drive unit that pulls these tapes through the production line. in between the entire forming and fixation process takes place, completely automated. the flat tapes are formed into their 3-dimensional geometry (in case of the l-sections) in the preforming unit and fixated in their shape by chemical stitching in the subsequent stitching and curing units. the report will now take a closer look at each individual subunit.  
storage unit  
as previously stated, the production of preforms begins with the material storage unit. in this unit four tape reels can be stored to be used in the preform production. the number of individual coils is not just governed by the amount of plies necessary to reach the desired laminate thickness, but also by the laminate design itself. this means that in components with different mechanical loads, taped of different fibre orientations will be used in order to tailor the mechanical properties of the laminate. for the spar preforms 0â° and â±45â° non-crimp fabric (ncf) carbon fibre tapes will be used. the 0â° tapes will be used predominantly in the spar caps (the l-sections), where tensile and compressive loads dominate. the straight 0â° fibres of the ncf are best suited to carry these loads. in the spar web, the doublers, shear loads dominate. thus, â±45â° tapes are used for the doublers since the main load direction of a shear force is in the â±45â° direction. however, because the tapes are pulled through the preforming line, a few 0â° glass fibres are introduced into the â±45â° tapes to stabilize them when being pulled. with the four coils in the material storage unit, all necessary material can be stored in the machine at all times. in the future, the material storage could be expanded to include more coils, if a wider variety of material is to be combines in one preform.  
preforming unit  
the preforming unit as is one of the central aspects of the automated preform production line. the preforming line will be able to produce two different geometries, the l-caps and the flat double webs. this will be possible without any changes to the preforming unit because two paths through the unit are possible. the lower, straight path forms the l sections, while for the flat doublers, for which no forming is necessary, the tapes are routed above the forming tool and back down at the end of the unit before the stitching unit. compared to the final design of the substructure the path of the flat doubler preform was changed to integrate it better with the other subunits. because the doublers and caps use different tapes as described in the previous paragraph, the production can be changed from one geometry to the next quickly. the l-section is formed by a set of rollers and a solid metal forming tool. first the rollers change the flat textile gradually from the flat tape into the final shape by increasing the angle of the l from 0â° to the final 100â° (outside angle). the solid forming tool then stabilises the preform until it can be fixated in the stitching and curing units.   
stitching unit  
that two component geometries are being fabricated on the same machine is also reflected in the design of the stitching unit, as seen in a top-down view in fig 9. during the stitching process two stitching heads inject small amounts of a 2-component resin between the textile layers. because of the constant movement of the textile substrate, the injection heads must move in a synchronized movement along the axis of production. the injection heads are therefore attached two linear drives that are synched up with the machine through a computer. in order to eliminate any chance of collision between the stitching heads, the linear drive are mounted behind each other even though the rows of stitching points made by each are parallel. the horizontal movement f the stitching heads in the machine x-direction (the direction of production) is overlaid with a motion orthogonal to the substrate. this is necessary to push the needle in between the textile layers, where the resin is to be deposited and pull it out again after all resin is at the correct place. this motion is either in the z-axis or the y-axis depending on the geometry of the preform. for the flat doublers, both injector heads perform virtually identical motions in the x and z-directions. for the l-sections though, because the two flanges are at an angle close to 90â°, one injector heads has to work in the y-direction (horizontally). for this, one injector head can be swung down and arrested in a second position to set the row of stitching points on the vertical frame.  
curing unit  
the curing unit is necessary to cure the resin injected as a form of preform stabilisation in the previous step. it consists of compaction section and the heating section. in the first section a series of rollers compact the textile layers again after the stitching process, and before the curing. after the curing, the injected resin points are hardened and the textile layers cannot be moved again. it must be made sure therefore, that before the resin is cured the preform is compacted to its desired thickness. the stitching points are cured by a set of infrared heaters. the length of the heating zone has been chosen that with the given power output of the heaters, the resin is fully cured while moving continuously along through the heating zone at the desired production speed.  
drive unit  
at the very end of the preform production line, sits the drive unit. the drive wheels are pressed down on the preforms and pull all textile layers through the entire production line. this way, the textile layers always under tension, which works against the formation of undulations due to compressive forces in the textile. it requires a small amount of 0â° fibres in â±45â° layers though, because usually pulling a â±45â° textile in the 0â° direction means strong deformation because â±45â° fibres cannot transmit the tensile loads of a 0â° pulling action.   
material and lay-up   
as lay-up a symmetrical stacking of (â±45/0)s was chosen for the spars. the doublers will contain the same material with a lay-up of (â±45/0/â±45). by choosing these stackings and textiles it was realised to use the same supply-coils for spars and doublers. the resulting fibre-volume content will be 54% for the spars and 59% for the doublers.  
preform production line  
an overview of the complete preform production line is given in fig 6, in which the subunits that are combined to form and fixate the preform are shown. the subunits demonstrate the modularized, flexible design of the preforming production line. to the right is the material store unit where the different textile tapes for the different geometries are stored as coils. to the far left is the drive unit that pulls these tapes through the production line. in between the entire forming and fixation process takes place, completely automated. the flat tapes are formed into their profile geometry (in case of the l-sections) in the preforming unit and fixated in their shape by chemical stitching in the subsequent stitching and curing units.   
  
assembly of prototype  
in order to validate the function of the basic preforming operation of the preform production line, the shape giving features of the device were tested. the spar caps (l-geometry) consist of four layers of non-crimp fabric (ncf). these layers are being reeled off the material store reels and combined into a flat stack before being fed into the preforming unit. the single layers have to be aligned precisely to form an even stack. any misalignment in this part of the production line will result in problems in the later units. the stack is being fed through solid shaping tools in the later steps. also, misalignment of the single layers cannot be corrected later in the production line so that any geometry deviation will manifest in out-of-tolerance parts in the end. the reels carrying the material are braked to ensure a constant tension on the layers.  
after the layers are combined the preforming unit forms the flat stack into an l-shaped profile. a set of rollers is used for a gradual forming of the flat tapes. the rollers only use little down force, to avoid damaging the fabric. their function is also not consolidation of the preform, which happens later in the production line but just shaping. the rollerâs shapes change from the right to the left, gradually increasing the angle of the âlâ shape. the down force of the rollers can be adjusted manually and is calibrated at the start of the production cycle. the down force is set so that the preform can be pulled through the entire production line without damaging the textile while at the same time forcing the flat tape into the desired shape.  
the preform is being passed through a solid shaping tool after the section with the rollers that has very little tolerance on any geometry deviations. if the preform can be fed through the tool it has exactly the necessary shape and is ready to be used in further processes.  
the maximum line speed that can be reached in the device is 1 m/min. the limiting factor is the synchronisation between the drives that move the injector head and the drive that pulls the preform through the line. the chemical stitching unit and subsequently also the curing unit were not used at this stage, because the special injectors for the chemical stitching could not be delivered in time. these steps will be done in the beginning of 2014.  
  
preform optimisation  
after the successful assembly and initial operation of the prototype preform production line, the process parameters could be adjusted to achieve a fast and stable process that produces high quality parts. the optimisation parameters are mostly interdependent, which mostly stems from the fact that two technologies, chemical stitching and continuous preforming, were combined in this project. the process parameters that were varied in the course of the process optimisation are the following:  
- line speed  
- continuous / semi continuous process  
- needle geometry  
- resin viscosity  
- stack consolidation /spread  
- injection pressure  
- injection time  
- other injection parameters  
in an integrated process such as the combination of automated preforming and chemical stitching in one device that was the centre of the project achso, the individual parameters are rarely independent of each other. changing one parameter often results in better performance in one part of the production line but worse performance in another. the interdependencies can often be estimated qualitatively but the exact influences of one on another are not known for new processes such as this. a lot of experience is necessary to achieve control over the process. this experience cannot be derived through other means as trial and error experiments.  
line speed is obviously important for the economic production of preforms. continuous production processes are deployed, when a high number of parts are needed. the line speed was chosen as the overall goal parameter in this process. as in many processes, production speed is inversely coupled with production quality. at low speeds an exact control of all parts of the integrated process line is possible, but production is not economic. increasing the speeds lets one usually produce quality parts until a certain cut off point is reached and the produced parts do not comply with the requirements anymore. following the philosophy of âas exact as necessary and not as exact as possibleâ this cut off point must be found. depending on the stability of the process and the tolerances of the requirements the set of parameters that bring one closest to this red line with a stable process must be found.  
the programming of the drives for pulling the fibre preform and for moving the injector heads let the user choose between two process states. firstly a continuous process that required parallel synchronised motion of the fibre preform substrate and the resin injector heads, this is the one that should be used for an economic process. secondly a semi-continuous process in which the movement of the fibre preforms was halted during the chemical stitching. no x-movement of the injector is necessary in this case. this mode should only be used in the set-up stage as it is considerably slower than the continuous one.   
however, it lets the user decouple the preforming and the chemical stitching processes. on the one hand this makes it easier to find the right parameters for each singular process. on the other hand, once going back to the continuous process the interdependencies between the two processes must be found, as described above. because the injectors that are responsible for the chemical stitching are a very complex system in itself, the semi-continuous process was used to understand their behaviour and produce stitch points that were considered acceptable. the next step was to produce these stitch points in the continuous process.  
in the stitching process alone several parameters can be adjusted. the resin itself can be varied in its viscosity. the reason to increase the viscosity is the behaviour of it in the textile preform. with the usual viscosity, the resin can be injected very easily between the preform layers, but is dispersed there in a wide area due to the capillary forces between the filaments. it is, in effect, sucked up by the fabric substrate like water by a cloth and cannot form a localised stitch point. the viscosity of the resin can be adjusted by adding calcium carbonate to the resin. the median size of the caco particles is 2.7 âµm so it can be dispersed in the liquid resin easily. increasing the resin viscosity, will make it harder and harder to transport it through the injectors and the needles into the preform. this will increase the time necessary to stitch one point, slowing down the process. it might also result in injection pressures that are too high for any of the parts involved, the weakest usually being the static mix tube. the concentration of caco was increased until the viscosity was high enough to sufficiently stay at the stitch point. the chosen mixture was resin weight to caco 1:1.4.   
to lower the injection pressure, a larger diameter needle might be used. the limit for the needle geometry is the ability to penetrate the preform. if the needle is too thick it might either not perforate the upper layers of the textile at all or damage the punctured fibres in a way that is detrimental to preform quality. the needle can penetrate the upper layers more easily it has a chamfered tip instead of a flat tip. this is turn smears the resin over a larger area in the z-direction (thickness), which can be positive or negative depending on the degree of consolidation that is chosen for the preform at this point. if the preform is strongly compacted the chamfering might result in spilling most of the resin on top of the preform because part of the needle opening sticks out of the textile stack. if, on the other hand, the layers are spread out the chamfering can aid in spreading the resin regularly between all the layers. a good compromise was found with needles of 0.84 mm diameter and a 20â° chamfered tip.  
the consolidation of the stack can be adjusted by adding rollers or spreaders in the area directly in front of the stitching area. in the forming part of the preforming line, a set of rollers is used to bring the flat material into the desired l-shape. this also leads to a pre-compaction of the textile stack. the consolidation of the textile stack during the stitching influences the final preform in several ways. with a high consolidation, the resistance for the resin to flow through the layers and wet each layer is high. the chance of failure to stitch all layers rises. on the other hand does a high degree of consolidation lead to a good, localised application of the resin and a small stitch point. if the resin in injected into a less consolidated stack later consolidation tend to smear the resin across a wider area. the lower consolidation raises the permeability of the stack and makes it thus easier for the resin to flow through the preform. this lowers injection pressures and injection time and ultimately leads to higher line speeds. to spread the layers after the pre-consolidation in the forming section, a comb can be placed directly in front of the stitching area. this separates the layers and creates a space between each of them into which the resin can flow without much resistance. in the end the comb was chosen over the extra roller to achieve greater separation and a better overall process.  
  
production of preforms  
in the report of the preceding deliverable d6-1, the process optimisation was described in detail. a number of interdependent parameters were adjusted to improve the prefo ...

# INSYSM

Project Acronym: INSYSM

programme & topic: FP7-PEOPLE FP7-PEOPLE-2009-IAPP

Most frequent returning words in objectives:

* ('insysm', 9)
* ('monitoring', 7)
* ('project', 6)
* ('structures', 5)
* ('handbook', 4)
* ('floods', 3)
* ('work', 3)
* ('smart', 3)
* ('textile', 3)
* ('procedures', 3)
* ('cities', 2)
* ('brought', 2)
* ('areas', 2)
* ('construction', 2)
* ('infrastructure', 2)
* ('earthquakes', 2)
* ('change', 2)
* ('buildings', 2)
* ('methods', 2)
* ('situations', 2)
* ('form', 2)
* ('toolbox', 2)
* ('time', 2)
* ('materials', 2)

about 30% of european citizens are concentrated in 500 largest cities of the continent. most of these cities are now subjected, or will be in the near future, to significant modification of their urban texture, brought about by the exploitation of new areas and by redevelopment of old industrial sites or the construction of big and pervasive infrastructure.  
urban areas modernization and natural calamities (floods, earthquakes, etc.) bring the change of the work conditions of urban infrastructure â in many cases historical buildings. the consequence of this change is the necessity of strengthening them. it has been observed, that traditional methods of strengthening buildings subjected to complex load layout do not always act in most effective way, oppositely, sometimes they have caused hazardous situations. insysm project offers new look into these problems, combining aspect of strengthening with sustained monitoring.  
  
within this project the objectives are twofold, on the one side insysm handbook and on the other self-monitoring smart textile for structural strengthening.  
the insysm handbook was created in the form of the toolbox of the procedures for retrofitting, strengthening, real time monitoring and maintenance of structures, specifically those impacted by complex situation of loads (i.e. seismic, paraseismic, mining deformations of subsoil, floods, transport, etc.). the toolbox focused on innovative techniques of structural upgrade with fibre-reinforced materials. it adapted the form of a handbook including description of reasons of structural damages, material properties, design methodology together with structural design procedures and examples, technological procedures for strengthening applications with examples, requirements and practical tips as well as methods of control. both handbook and additional materials providing explanations are available to download at the project website.   
elaborated during project realization it was meant to meet the needs of structural engineering in field of strengthening and monitoring existing structures. performed tests on different type of structural elements, including concrete, timber and masonry structures, allowed to prepare credible tool for structural monitoring being at the same time structural strengthening itself. insysm team analysed many different aspects for this structurally verified solution: measurements of various important factors, as for example temperature and humidity, wifi transfer of data, including transfer through massive concrete blocks, textile antennas and energy harvesting. calibrating works will be still continued after projectâs termination. at the end of the project insysm consortium registered first patent for the prototype of smart strengthening.   
  
insysm project creates innovative strengthening and sensing technologies based on the textile industry experiences. strengthening equipped with monitoring system enables very powerful advantages. during all of the work phases collected measurements can picture performance of a whole structure, which can be used for continuous observation of the building and shall allow to master the strengthening solutions due to building real life work, also during accidental situations like floods, earthquakes etc.   
economical crisis in europe of last years brought also another important value to this solution â it provides an option for relatively cheap monitoring and strengthening for existing seriously deteriorated large structures, especially bridges vs expensive diagnosing or construction of new structure.  
  
the works started with insysm will be continued, developed and disseminated by all the partners of the consortium. the idea of smart textiles, strengthening and monitoring structures draw attention of several universities, institutions and enterprises in different countries also outside eu.   
  
  
insysm website: insysm.polsl.pl  
contact to insysm coordinator: marcin.gorski@polsl.pl

# TRADE

Project Acronym: TRADE

programme & topic: FP7-PEOPLE FP7-PEOPLE-2012-IEF

Most frequent returning words in objectives:

* ('research', 27)
* ('textile', 16)
* ('fellow', 16)
* ('university', 12)
* ('museum', 11)
* ('fashion', 10)
* ('history', 9)
* ('centre', 7)
* ('trade', 6)
* ('copenhagen', 6)
* ('dress', 6)
* ('hohti', 5)
* ('course', 5)
* ('fellowship', 5)
* ('experimental', 5)
* ('culture', 4)
* ('project', 4)
* ('period', 4)
* ('methods', 4)
* ('archaeology', 4)
* ('knowledge', 4)
* ('europe', 4)
* ('denmark', 4)
* ('training', 4)

global encounters: fashion, culture and foreign trade in scandinavia, 1500-1630  
  
the ief project, titled âglobal encounters: fashion, culture and foreign trade in scandinavia, 1500-1630â, carried out at the danish national research foundationâs centre for textile research, university of copenhagen, by the fellow dr paula hohti, investigated how international trade and european tastes for fashionable goods changed scandinavian cultures in the early modern period, 1500-1630. using a wide range of methods from different disciplines, including art and cultural history, archaeology, anthropology, economic and social history, and fashion theory, it explored what economic, social and stylistic changes were introduced by foreign imports into the local scandinavian cultures, how the lives of individuals were visually transformed by novel cultural concepts, and, eventually, what constituted scandinavian fashions in the early modern period.   
  
in the course of the research in historical archives in finland and sweden, the fellow dr hohti identified and discovered a number of important visual sources and documents, including wardrobe inventories, commercial letters, trade records and account books, that provided new knowledge about fashion and cross-cultural exchanges in scandinavia in the period 1500-1630. these documents have allowed her to demonstrate that scandinavian area along the baltic trade route was culturally much less isolated than some of the current scholarship has assumed. foreign fabrics and clothing products were imported to the scandinavian towns of copenhagen, malmã¶, stockholm and turku from diverse european geographical areas, e.g. england, flanders, germany, spain and italy. these included novelties and new fashion accessories such as knitted hats and luxury fabrics that were ordered for weddings and other festive occasions. finnish, swedish and danish noble families had also direct contacts and contracts with great european merchants, which meant that scandinavians could also get hold of non-european goods that had arrived in europe through the international ports in venice, genoa, lisbon and spain. the results of the marie curie fellowship research were shared through a number of publications and academic papers, given in international conferences in museums and universities, such as the national museum of denmark, european university in florence, bard graduate college in new york, museum of applied arts in vienna and the centre for fashion studies in stockholm. these scholarly lectures have enabled the fellow dr hohti to contribute to the ongoing debates concerning economic, social and cultural change in early modern europe. as a result, the fellow was invited to contribute to important international publications of the field, including the forthcoming collection of essays luxury and the ethics of greed in the early modern world, ed. by catherine kovesi, to appear in 2016, and the bloomsbury cultural history series cultural history of the home: the renaissance, 1450-1650 (ed. by amanda j. flather, 2016).  
  
new methods in early modern textile and dress history  
  
one of the central goals of the project was also to develop a new methodology merging theoretical and practical approaches to early modern european textile and fashion research. during the intra-european fellowship, the fellow combined her previous art historical training and theoretical and empirical approach with new practical work in textile artefacts through museum work, experimental archaeology, scientific analyses and the study of textile techniques. as part of the training, the fellow undertook several courses on historical textiles and textile technologies, for example, at the textile research centre in leiden, the istituto lisio in florence, and the experimental research centre at lejre, denmark, learning how historical textiles were actually made and dyed, and what kind of stages were involved in the processes of production in the early modern period. the fellowâs strong focus in dress and textile research at both scientific and experimental levels resulted in several workshops that were created and convened in collaboration with several museum curators and university scholars in europe and the us. in november, 2014, for example, the fellow organised a workshop at the centre of textile research at the metropolitan museum of art and the ratti textile research in new york, where the research centreâs fellows were introduced to the methods of conservation, research and textile storage systems of the museum. during the same research trip, the fellow also chaired a lecture on new methods in textile research at bard graduate centre, new york.  
  
this framework of dress and textile research at both scientific and experimental levels led to more comprehensive questions about the interpretation of the value, origins and stylistic variations associated with dress and textile items. however, at the same time, it complicated the question of what does it actually mean, methodologically, for a historian to integrate these experiments in early modern research. this aspect was explored in february 2015 in the workshop âexperimental archaeology and early modern historyâ, organised by the fellow in collaboration with her colleague, the archaeologist dr eva andersson strand. the aim was to investigate differences between experimental and experience research, and to evaluate how these can be applied in historical textile research. this approach will be strengthened at aalto university, school of arts, design and architecture, where the fellow was recruited immediately after her ief in spring 2015.   
   
   
research management training  
in order to give the fellow the opportunity to gain experience of building up and directing her own research group, the host institution ctr gave additional funding of 100.000 dkk for the fellow to set up the research programme clothing, costume, consumption and culture (cccc), run between the university of copenhagen and the national museum of denmark. as the leader of the research programme, the fellow was responsible for five ph.d. students and a large network of established interdisciplinary, international academic researchers and museum curators. the international partners were warwick university, glasgow university, uk, and the europe university in florence. within this research programme the fellow organised and convened in collaboration with the doctoral students and international partners two workshops and a conference, held at the university of copenhagen, the museum of copenhagen, the national museum of denmark and at the global history centre, university of warwick. these events addressed issues of global trade of textile and clothing, and the key-note speakers included leading scholars of the field, prof. giorgio riello and prof. john styles.   
  
ma-level course âdress and fashion in early modern europeâ   
as part of the training and research of the marie curie mobility fellowship, the fellow also designed and taught a one-semester course, âdress and fashion in early modern europeâ at the university of copenhagen. the goal of the course, taught in english, was to provide the students not only with new knowledge about historical dress, but also about how historical knowledge is being created in different academic fields. the range of topics were explored from various points of view by inviting guest lecturers from the fields of archaeology, art and cultural history, social and economic history and museum conservation. as a result, the course gave the students a new interdisciplinary âtool kitâ how to study historical dress, textiles and fashion.   
  
the blog âglobal encountersâ   
an important objective of this fellowship was to disseminate knowledge about academic research outside academia. the fellow approached and fulfilled this objective in a very successful and innovative way by creating a research blog which offered a global readership the possibility to follow her ongoing research live, following the creative path of intellectual work and the choices that were made. the blog was a powerful and useful tool to communicate and publish the results immediately to a global audience of so far over 9000 followers.  
  
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project websites:   
  
cccc: http://ctr.hum.ku.dk/costumes\_clothing\_consumption\_culture/  
project: http://ctr.hum.ku.dk/costumes\_clothing\_consumption\_culture/global\_encounters/  
dr. hohti http://ctr.hum.ku.dk/people/staff-list/?pure=en/persons/445564

# TRADE

Project Acronym: TRADE

programme & topic: FP7-PEOPLE FP7-PEOPLE-2012-IEF

Most frequent returning words in objectives:

* ('research', 27)
* ('textile', 16)
* ('fellow', 16)
* ('university', 12)
* ('museum', 11)
* ('fashion', 10)
* ('history', 9)
* ('centre', 7)
* ('trade', 6)
* ('copenhagen', 6)
* ('dress', 6)
* ('hohti', 5)
* ('course', 5)
* ('fellowship', 5)
* ('experimental', 5)
* ('culture', 4)
* ('project', 4)
* ('period', 4)
* ('methods', 4)
* ('archaeology', 4)
* ('knowledge', 4)
* ('europe', 4)
* ('denmark', 4)
* ('training', 4)

global encounters: fashion, culture and foreign trade in scandinavia, 1500-1630  
  
the ief project, titled âglobal encounters: fashion, culture and foreign trade in scandinavia, 1500-1630â, carried out at the danish national research foundationâs centre for textile research, university of copenhagen, by the fellow dr paula hohti, investigated how international trade and european tastes for fashionable goods changed scandinavian cultures in the early modern period, 1500-1630. using a wide range of methods from different disciplines, including art and cultural history, archaeology, anthropology, economic and social history, and fashion theory, it explored what economic, social and stylistic changes were introduced by foreign imports into the local scandinavian cultures, how the lives of individuals were visually transformed by novel cultural concepts, and, eventually, what constituted scandinavian fashions in the early modern period.   
  
in the course of the research in historical archives in finland and sweden, the fellow dr hohti identified and discovered a number of important visual sources and documents, including wardrobe inventories, commercial letters, trade records and account books, that provided new knowledge about fashion and cross-cultural exchanges in scandinavia in the period 1500-1630. these documents have allowed her to demonstrate that scandinavian area along the baltic trade route was culturally much less isolated than some of the current scholarship has assumed. foreign fabrics and clothing products were imported to the scandinavian towns of copenhagen, malmã¶, stockholm and turku from diverse european geographical areas, e.g. england, flanders, germany, spain and italy. these included novelties and new fashion accessories such as knitted hats and luxury fabrics that were ordered for weddings and other festive occasions. finnish, swedish and danish noble families had also direct contacts and contracts with great european merchants, which meant that scandinavians could also get hold of non-european goods that had arrived in europe through the international ports in venice, genoa, lisbon and spain. the results of the marie curie fellowship research were shared through a number of publications and academic papers, given in international conferences in museums and universities, such as the national museum of denmark, european university in florence, bard graduate college in new york, museum of applied arts in vienna and the centre for fashion studies in stockholm. these scholarly lectures have enabled the fellow dr hohti to contribute to the ongoing debates concerning economic, social and cultural change in early modern europe. as a result, the fellow was invited to contribute to important international publications of the field, including the forthcoming collection of essays luxury and the ethics of greed in the early modern world, ed. by catherine kovesi, to appear in 2016, and the bloomsbury cultural history series cultural history of the home: the renaissance, 1450-1650 (ed. by amanda j. flather, 2016).  
  
new methods in early modern textile and dress history  
  
one of the central goals of the project was also to develop a new methodology merging theoretical and practical approaches to early modern european textile and fashion research. during the intra-european fellowship, the fellow combined her previous art historical training and theoretical and empirical approach with new practical work in textile artefacts through museum work, experimental archaeology, scientific analyses and the study of textile techniques. as part of the training, the fellow undertook several courses on historical textiles and textile technologies, for example, at the textile research centre in leiden, the istituto lisio in florence, and the experimental research centre at lejre, denmark, learning how historical textiles were actually made and dyed, and what kind of stages were involved in the processes of production in the early modern period. the fellowâs strong focus in dress and textile research at both scientific and experimental levels resulted in several workshops that were created and convened in collaboration with several museum curators and university scholars in europe and the us. in november, 2014, for example, the fellow organised a workshop at the centre of textile research at the metropolitan museum of art and the ratti textile research in new york, where the research centreâs fellows were introduced to the methods of conservation, research and textile storage systems of the museum. during the same research trip, the fellow also chaired a lecture on new methods in textile research at bard graduate centre, new york.  
  
this framework of dress and textile research at both scientific and experimental levels led to more comprehensive questions about the interpretation of the value, origins and stylistic variations associated with dress and textile items. however, at the same time, it complicated the question of what does it actually mean, methodologically, for a historian to integrate these experiments in early modern research. this aspect was explored in february 2015 in the workshop âexperimental archaeology and early modern historyâ, organised by the fellow in collaboration with her colleague, the archaeologist dr eva andersson strand. the aim was to investigate differences between experimental and experience research, and to evaluate how these can be applied in historical textile research. this approach will be strengthened at aalto university, school of arts, design and architecture, where the fellow was recruited immediately after her ief in spring 2015.   
   
   
research management training  
in order to give the fellow the opportunity to gain experience of building up and directing her own research group, the host institution ctr gave additional funding of 100.000 dkk for the fellow to set up the research programme clothing, costume, consumption and culture (cccc), run between the university of copenhagen and the national museum of denmark. as the leader of the research programme, the fellow was responsible for five ph.d. students and a large network of established interdisciplinary, international academic researchers and museum curators. the international partners were warwick university, glasgow university, uk, and the europe university in florence. within this research programme the fellow organised and convened in collaboration with the doctoral students and international partners two workshops and a conference, held at the university of copenhagen, the museum of copenhagen, the national museum of denmark and at the global history centre, university of warwick. these events addressed issues of global trade of textile and clothing, and the key-note speakers included leading scholars of the field, prof. giorgio riello and prof. john styles.   
  
ma-level course âdress and fashion in early modern europeâ   
as part of the training and research of the marie curie mobility fellowship, the fellow also designed and taught a one-semester course, âdress and fashion in early modern europeâ at the university of copenhagen. the goal of the course, taught in english, was to provide the students not only with new knowledge about historical dress, but also about how historical knowledge is being created in different academic fields. the range of topics were explored from various points of view by inviting guest lecturers from the fields of archaeology, art and cultural history, social and economic history and museum conservation. as a result, the course gave the students a new interdisciplinary âtool kitâ how to study historical dress, textiles and fashion.   
  
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# INNOVATIVE SPINNING

Project Acronym: INNOVATIVE SPINNING

programme & topic: FP7-PEOPLE FP7-PEOPLE-2009-IAPP

Most frequent returning words in objectives:

* ('rotor', 7)
* ('system', 7)
* ('quality', 4)
* ('yarn', 3)
* ('novel', 2)
* ('bearings', 2)
* ('industry', 2)
* ('market', 2)
* ('compact', 2)
* ('radial', 2)
* ('position', 2)
* ('reduction', 2)
* ('goal', 1)
* ('project', 1)
* ('realise', 1)
* ('worldwide', 1)
* ('unique', 1)
* ('concept', 1)
* ('combination', 1)
* ('efficiency', 1)
* ('brushless', 1)
* ('bldc', 1)
* ('motor', 1)
* ('textile', 1)

the goal of the proposed project is to realise a novel and worldwide unique rotor spinning concept with superior yarn quality by the use of active magnetic bearings in combination with a high efficiency brushless direct current (bldc) motor.   
  
currently, rotor spinning is most common in the textile industry. the yarn quality is high and the technique is well-known, but the method is labour-intensive and lacks output performance. therefore the emerging trend in industrial spinning is a special type of open-end rotor spinning.   
the european manufacturers of rotor spinning machines are few, of high quality and clearly arranged. these companies possess a technology advance against low-cost and low-quality competitors, which are mainly located outside the european union. to keep up the leadership in the spinning industry the potential of magnetic bearings in this market sector has to be exploited.   
the basis for the novel approach of the consortium is utilizing a disk shaped magnetically suspended rotor so it becomes possible to design very compact bearingless system. in this case three degrees of freedom (the radial and tilting directions) can be stabilized passively by means of reluctance forces. therefore, only the radial rotor position and the rotor angle have to be controlled actively by stator coils.   
however, five main technical problems have been identified which still oppose a successful implementation of an industrial product into the market.   
  
the first objective was the development of a reliable and robust position sensing system.   
  
the second challenge was the integration of the spinning system into a highly sophisticated compact smart system.  
  
the third assignment was the reduction of air drag. a reduction of over 30% of the air friction loss was achieved.  
  
the fourth duty was the improvement of dynamic robustness by scientific system analysis.   
  
the final task was the optimization of the spinning system and the spinning process to improve the yarn quality  
  
in general following research methodswere be applied: literature surveys, finite element simulations, all kinds of modelling, experimental approaches, different verification methods, system designing.

# TEXTILESTUDIES

Project Acronym: TEXTILESTUDIES

programme & topic: FP7-PEOPLE FP7-PEOPLE-2013-IEF

Most frequent returning words in objectives:

* ('research', 16)
* ('textile', 11)
* ('study', 10)
* ('project', 9)
* ('practices', 9)
* ('fellow', 8)
* ('knowledge', 7)
* ('technology', 6)
* ('carraro', 6)
* ('university', 6)
* ('experimental', 5)
* ('regard', 5)
* ('textiles', 4)
* ('history', 4)
* ('analysis', 4)
* ('frame', 4)
* ('centre', 4)
* ('collaboration', 4)
* ('anthropology', 4)
* ('artefacts', 3)
* ('sciences', 3)
* ('humanities', 3)
* ('focus', 3)
* ('archaeology', 3)

the project have consisted in an anthropological study and in an ethnographic enquiry among and with textile experts aimed at exploring the research practices that guide and generate the âreconstructionâ of the ancient technological textile practices - from the artefacts to the technology to the technique. in particular, the investigation has addressed the intersection of the natural sciences, humanities, experimental methods and technical skilled practices as they are involved and/or mobilized into the study of the ancient textiles. the focus has been on the relationship between knowledge and knowhow as specific as well as complementary knowing and knowledge making processes. two main axes have been followed. the first has focused on scholarly literature, schemas and practices with special focus on archaeology, philology, history of technology for the humanities, and geology and biology for the natural sciences. the second axe has concerned textile objects and techniques (artefacts, materials, tools and processes) through the analysis of the experimental protocols, experience-based practices and hands-on approaches developed by and with craftspeople with special focus on the textile chaã®ne opã©ratoire and cours d'action. within the frame of the ethnographical enquiry, interviews and observations have been conducted by the fellow in european universities, research centres and institutions, museums and workshops with the actors of the study: scholars, technicians, curators, professional weavers and craftspeople. furthermore, the ethnographic approach and the reflexive research stance adopted have allowed the fellow to match the fieldwork research and the specific training within the frame of her marie curie project. by this, dr carraro has implemented a participant and applied research. the textile technology, techniques and technical system have been analysed from a structural, historical and functional points of view, and the knowing practices, structures and devices implied in the study of the archaeological textiles have been described and studied in a symmetrical way following the project's objectives. in particular, starting from the ctr and partner research institutions' ongoing projects on the mediterranean (aegean, greek and etruscan) and scandinavian archaeological textiles, the investigation have been conducted through a wider textile network in denmark (ctr, lejre experimental centre, danish national centre for isotope geology and department of conservation of the danish national museum) and abroad, mainly in france (cieta and cne - cnrs) and italy (university of rome la sapienza, museo delle origini and fondazione arte della seta lisio). within the collaboration with the laboratory for techno-functional analysis of pre- and protohistoric artefacts (latfpa) headed by prof. cristina lemorini at the museo delle origini and university of rome la sapienza, the fellow has conducted a comparative study in experimental archaeology with regard to other technologies from the past and integrated ethnographical data (see the report letter by prof. lemorini in attachment). by this double perspective, dr carraro's project has implemented on a new basis the dialogue between anthropology, ethnology and archaeology. fieldwork research and training with professional weavers - in denmark mainly with karen-hanne staermose nielsen, in france at the cieta and in italy at the fondazione lisio and in traditional and modern workshops â have allowed the fellow to integrate the technological dimensions of the textile production into the analysis. in this regard, of a relevant interest is the programme launched by the fellow with assunta perilli at the lejre experimental centre, at the university of la sapienza and with the fondazione arte della seta lisio on textile traditional and archaeological protocols and tools. in particular, the two editions of the event and research workshop âfilo da torcereâ organized at campotosto (aq) in october 2015 and june 2016 in collaboration also with m. gleba (cambridge university) has involved research institutions, professionals and general public (see attachments). a 3rd workshop, scheduled in october 2016, is in preparation. the analyses developed and the data collected in these frames have been matched with the study of the heterogeneous scholarly knowledge practices, habits and schemas. by this, the fellow has been able to address the issue of interdisciplinarity on empirical bases and from a theoretical and methodological points of view. in this regard, dr carraro has organized two scientific workshops in 2015 in collaboration with prof. claus emmeche, department of science of education, and the humanomics research centre: âaspects of interdisciplinarityâ (ucph) (see attachment) and âlearning interdisciplinarityâ (ucph and university of aarhus). in particular, the fellow's collaboration since the beginning of the mc project with dr ellen harlizius klã¼ck, guest researcher at ctr, on the history and anthropology of textile technology and thought generated a very rich synergy and has involved researchers from ctr and the university of leeds. most importantly, within the frame of this collaborative work, the fellow has contributed to the elaboration of the application for the erc consolidator grant of p.i. dr ellen harlizius klã¼ck and is part of the research team of the project âpenelopeâ. this project has been funded and dr carraro will start her work within this frame at the research institute for the history of science and technology of deutsches museum in munich since fall 2016 as direct continuation and result of her marie curie project. as planned in the application, the objectives and results of the research can be situated with regard to four axes: anthropology of technology; science studies; history, sociology and anthropology of knowledge; textile studies. the short and long-term impact of dr carraro's marie curie project can be appreciated with regard to these research fields. for the first time a deep and empirical based study on research practices in the field of textile studies has been conducted enhancing the understanding of the composite and high specialized knowledge involved in this often marginalized field of study. furthermore, the study of the research practices in inter- and multidisciplinarity conducted by dr carraro potentially allows us to improve the analysis of knowledge production in sciences and humanities as well as in their applied dimensions bridging the gap of the main dichotomies of knowledge and knowhow and thus laying the groundwork for further discussions and perspectives far beyond the case study of the archaeological textiles.

# TEXTILESTUDIES

Project Acronym: TEXTILESTUDIES

programme & topic: FP7-PEOPLE FP7-PEOPLE-2013-IEF

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* ('textile', 11)
* ('study', 10)
* ('project', 9)
* ('practices', 9)
* ('fellow', 8)
* ('knowledge', 7)
* ('technology', 6)
* ('carraro', 6)
* ('university', 6)
* ('experimental', 5)
* ('regard', 5)
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* ('humanities', 3)
* ('focus', 3)
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# SAFE@SEA

Project Acronym: SAFE@SEA

programme & topic: FP7-NMP NMP-2008-4.0-9

Most frequent returning words in objectives:

* ('work', 38)
* ('materials', 38)
* ('clothing', 34)
* ('development', 33)
* ('developed', 32)
* ('fishermen', 30)
* ('concept', 26)
* ('protection', 26)
* ('system', 22)
* ('buoyancy', 21)
* ('user', 21)
* ('material', 21)
* ('prototypes', 19)
* ('protective', 18)
* ('project', 17)
* ('integration', 17)
* ('unit', 17)
* ('task', 16)
* ('safety', 15)
* ('solutions', 15)
* ('properties', 15)
* ('head', 14)
* ('comfort', 13)
* ('headgear', 13)

executive summary:  
  
the main objective of safe@sea has been to develop new protective clothing for fishermen that will lead to a significant increase in safety without reducing work performance.  
  
fishing is among the most risk exposed of all occupations. the work is characterized by hazardous working conditions, strenuous labor, long work hours, harsh weather and heavy waves. common accidents include entanglement, cut or crush injuries, being hit by gear or falling over board. a review of niosh data from 2000-2010 showed that 31% of all fatalities in the fisheries occurred when fishermen fell overboard. despite the discouraging statistics, fishermen report that they rarely wear buoyancy aids while working on deck.  
  
project context and objectives:  
  
the main objective of safe@sea is to develop a new generation of advanced personal protective clothing for the fishing industry that will lead to a significant increase in safety without reducing work performance.  
  
the main concept behind safe@sea is to combine integration of "state of art" materials and ict solutions with the development of new speciality and high-performance protective materials to realise a totally new protective clothing concept. the increased safety will be provided by improved solutions for buoyancy, thermal protection, tear and puncture resistance, head and hand protection, emergency warning and positioning systems. the advanced personal protective clothing system will be designed to satisfy end-users requirements for multi-functionality, ergonomic design and comfort in order to ensure user acceptance.  
  
background  
the food and agriculture organization of the united nations estimates that 28.5 million people around the world work in fishing and fish farming. according to the international labour organization (ilo), fishing is among the most dangerous of all professions with as many as 24,000 fishermen around the world killed every year. many commercial fishing operations are characterized by hazardous working conditions, strenuous labour, long work hours and harsh weather. according to niosh an annual average of 46 deaths occurred (124 deaths per 100,000 workers), compared with an average of 5,5 deaths (4 per 100,000 workers) among all us workers in the period 2000-2010 . reports from iceland indicate that yearly, 10 % of all fishermen and 15% of fishermen on trawlers suffer injuries. improved safety at sea is a major concern for national authorities, international organizations and nongovernmental organisations.  
  
capsizing, grounding and collisions are some of the main reasons for fatal accidents in the fishing fleet (44%), with 26% of all accidents in the fishing industry involving fishermen drowning as a result of falling or being pulled overboard . fishermen are highly vulnerable at work and being crushed or hit by gear are common accidents. particularly on board larger vessels, such as trawlers, the risk of being hit by falling or flying objects is high. another risk factor is the extreme working situations with cold, harsh weather and heavy waves. cold produces physical and mental stress in the individual that may lead to reductions in both work performance and safety. efficiency and safety are compromised by inadequate protective clothing for this environment.  
  
basis for the safe@sea concept â high potential for improved safety in fisheries  
existing solutions for integrated buoyancy in maritime workwear do not satisfy users' demands for functionality and comfort. new buoyancy solutions which gain user acceptance have a high potential for preventing drowning. the development of improved scratch, tear-, wear- and puncture-resistant materials, and materials with self-repairing abilities, will keep fishermen dry and warm, and protect them from cuts and injuries.  
  
overview of the work packages, objectives and their interaction:  
to realize the main objective of safe@sea, the following scientific and technological sub-goals was established and addressed in different work packages:  
  
wp1 management of the project and consortium, including linking together all the projects components and maintaining communication with the commission.  
  
wp2 obtain an in-depth understanding of the fishermen's working environment and identify possible differences between european fishing countries. define a total specification of requirements to personal protective equipment for fishermen. this work package ensures the close linkage of user needs and market possibilities with concept and technology development in wp3, wp4 and wp5.  
  
wp3 development of overall concepts for ppe (work clothing, head protection and gloves), integrating functionalities defined in wp2. selection and integration of the best combination of materials and ict technologies developed in wp 4 and 5, design and development of intermediate prototypes. manufacture of the optimized final prototype total clothing system for fishermen  
  
wp4 development of new specialty and high-performance materials for integration into protective clothing (work clothing, head protection and gloves) capable of maintaining high comfort levels:  
1) development and integration of new fabrics with improved tear strength and resistance to penetration of sharp objects through high strength fibres and yarns. 2) development of coated materials with improved scratch and wear resistance as well as stain/dirt repellence and comfort. 3) developments of materials with self-repair functions will be integrated in existing coatings materials to restore the protective outer layer on garments damaged by subjection to daily wear and tear. 4) new structures and material combinations for buoyancy involving lightweight and flexible materials. 5) integrate shock absorber materials for head protection to protect against falling objects and prevent crushing or injury from flying gear 6) the feasibility and processibility of the new developed materials and prototypes will be evaluated of the sme partners.  
  
wp5 integrate electronics (e.g sensors, antenna) into protective outer garments that support alerting, localisation and possible emergency stop systems in clothing. the goal is to ensure robustness to the highly corrosive wet and salt environment whilst enabling integration of personal safety functions without compromising garment comfort for end-users. wp 5 ict solutions will be developed and where possible, integrated into material structures having impact on material development in wp 4. concept development in wp 3 will influence material developments in wp 4. development tests on material level will be part of wp 4 and wp 5. verification tests on prototypes, as well as field tests will be performed in wp 6/wp9  
  
wp6 ensure that the properties of developed materials and design solutions correspond to the requirements defined in wp2 and defined standards. protection, safety and comfort aspects will be evaluated in realistic controlled test conditions and on board fishing vessels.  
  
wp7 integrate the developed technology into a holistic system of functional prototypes for protective fishermen's clothing and define and specify realistic processes for the industrialisation of the technological developments employed in the manufactured prototypes. this includes a handbook for manufacture, standardization issues, cost analysis, health, safety and environmental issues. undertake an analysis of costs associated with technology integration/adoption proposals as part of the testing and validation process. assess the ability of prototypes to meet the main project objectives for user acceptance. fine tune concepts to end user preferences and target market price points in relevant segments.   
  
wp 8 disseminate public information about the safe@sea total clothing system developed for fishermen assessing interest displayed in developed products and methods, and evaluating the expected economic of safe@sea developments on the market. to broadcast the benefits of the developed technology to potential end-users and interest organisations, once innovations are duly protected.   
  
wp 9 the viability of the new technology for fishermen's clothing that cannot be commercialised directly will be proven in 1) micro scale testing of new materials and ict solutions 2) macro scale testing of final prototypes of fishermen clothing. a technology and product implementation plan will be developed.  
  
project results:  
  
main science and technology (s&t) results  
  
in the following the main scientific and technological results from the safe@sea project will be presented for each work package.  
  
wp2 specifications  
the purpose of wp2 has been to provide the project with knowledge of the fishermen's preferences and needs regarding protective clothing, in order to set guidelines for the concept development and promote user acceptance of the developed protective clothing. based on this knowledge, wp2 have worked to ensure implementation of solutions that meet these user preferences/needs in the final clothing concept. wp2 links the user needs and market possibilities with the concept and technology development in wp3, wp4 and wp5. the safe@sea project has developed a clothing concept in accordance with user needs and preferences by following a user-focused product development process.  
  
the overall objectives of wp2 were to i) gather an overview of existing commercially available products, ii) obtain in-depth understanding of the fishermen's working environment and situation, and iii) develop a specification of user requirements for the total personal clothing concept for fishermen. these objectives are met by the completion of four tasks; i) task 2.1 screening of market possibilities and user needs, ii) task 2.2 paramount requirements, market and user needs, iii) task 2.3 identification of detailed needs and specifications and finally iv) task 2.4 total requirements.  
  
wp3 concept development and prototyping  
specifications and technical results coming from all work packages flow together to build up the total clothing development in work package 3. based on user requirements identified in wp2, different overall concepts for a novel ppe system were developed within the work package 3.  
the main objectives of this work package are listed below:  
- develop overall concepts for ppe, integrating functionalities defined in wp2;  
- develop hybrid textile based samples, integrating materials and ict solutions developed in wp4 and wp5;  
- select the best combination of materials and technologies, design and development of intermediate prototypes;  
- manufacture the optimized final prototype total clothing system for fishermen.  
  
the safe@sea project followed a user-focused development process. from wp2, the user's needs, preferences and prioritized functionalities were indicated, and the main functionalities of the clothing concept were identified. the idea generation and consequently the creation of concept samples are based on those findings from wp2 and available in the deliverable 3.1 preliminary concept development. the concept samples include some of the features which are possible to evaluate in a total clothing system as well as in hybrid multilayered patches. based on workshops, brainstorming and partners feedback coming from different backgrounds, the design ideas were modified and developed more in-depth concept illustrations. during this task each user requirement coming from a list of priority has been corresponded to a combination of design/material and ict solutions.  
  
  
wp4 development and integration of materials  
the main objective of wp4 was to develop new specialty and high-performance materials for integration into protective clothing capable of maintaining high comfort levels. activities in wp4 have been focused on developing material solutions and technologies to improve performance and facilitate required functionality. in task 4.1, focus has been in developing textile materials for protection against sharp objects (mainly knifes), including evaluation on methods on testing cut resistance. base material for large area integration as well as reinforcement material has been developed. in task 4.2 coatings has been developed for the new textile fabrics. several new technologies have been integrated in today's state of the market pur-based coatings. sol-gel particles and poss molecules are examples of technologies developed for integration in the coating system. in the end these technologies didn't improve the functionality and was not integrated in the final coating. instead a pur-system with special additives was chosen. task 4.3 focused on self healing micro capsules for integration in the coating concept. the work with development of microcapsules and integrating them in the coating in order to heal smaller damages and prevent water leakage did almost succeed during project time. but still there are some hours left in the lab before the up-scaling can start. then, in task 4.4, buoyancy concepts have been developed facilitating life-saving flotation aid integrated in the clothing system. since separate flotation aid (life vests) is limiting work performance, special attention has been put on optimizing work ergonomic and freedom of movement. in task 4.5 development of head protection have been focusing on finding material solutions giving acceptable impact and puncture protection combined with high work ergonomics. prototypes have been developed based on three concept designs, rigid, semi-rigid and flexible. a summer and a winter version of each model were appreciated by the fishermen. regarding gloves, two concepts have been developed; a one-layer glove and a three-layer glove.  
  
t 4.1 development and integration of new fabrics with improved tear strength and resistance to penetration of sharp objects  
during the development work of a cut resistance fabric for gloves in the safe@sea project, it was found that none of these existing methods measure the cut resistance in fabric as it could be in a real life scenario for fishermen. the sharp rotating wheel in the coup text machine used in en388 favors materials with a high melting point and the in the tdm100 machine used in astm f1790-05 and en iso 13997 a sharp blade is used. since electricity is used to measure when the wheel and blade have cut trough, steel fibers could raise difficulties. a new test method was developed where a commonly used knife is fitted to a frame and used to make a straight cut across the fabric or the product using a suitable backing material. the length of cut-through is evaluated. the statistical screening investigation showed that all tested settings affect the cut length.  
  
t4.2 development of coated materials with improved scratch and wear resistance as well as stain/dirt repellence and comfort  
several coating system have been developed and tested during the project. sol-gel technology and poss-molecules didn't improve the most important properties. a coating with base- and top layer of polyurethane with abrasion resistant additives were chosen to the concept.  
  
coating: sol-gel approach  
for the first route literature screening of sol-gel technologies has been done. several sol-gel products were selected and applied onto pes and pa fabric supplied by fov. the standard martindale abrasion method for durability testing showed to be not sufficiently heavy enough for the application. therefore the test setup was modified: the wool tissue which is used as standard abradant was replaced with sand paper. testing with this method shows that a textile outer layer with finishing will be too weak compared to coated outer material. several types of sol-gel particles were incorporated in the pu top layer (see below) to see the effect on the abrasion resistance and waterproofness. no improved abrasion resistance was found; in several cases a deterioration of the durability was even seen.  
  
coating: pu-coating approach  
for the second route different types of scratch resistant and waterproof materials have been investigated. it was decided to avoid the use of pvc and focus on non-solvent based polyurethanes as the water based materials have a lower ecological impact.  
  
mob unit  
in the first instance it was tested if the antenna attached to the fabric could be directly coated (knife-on-roll) with the same pu as used for the whole garment. no homogeneous coating layer could be obtained. another approach to encapsulate the antenna was necessary.  
  
both fluorocarbon-pretreated and -unpretreated samples of the pa fabric were coated and delivered to ohmatex to evaluate the difference of the adhesion of the mob unit to the coated fabric.  
  
the encapsulated mob unit developed by ohmatex is sensitive to fish oil staining. in order to improve the fish oil repellency the mob unit was finished with bemiguard eco rt (1 wt%, aqueous solution) in the presence of a wetting agent. since the polymer material of the unit is not compatible with water, marks were visible on the surface of the unit after drying at 60â°c for 2 hours (drying at 100â°c affects the mob unit). fish oil tests were performed by tut in wp6.  
  
gloves  
in order to improve the antislip properties of the knit used for the gloves, it was treated via dip-padding with several types of binders. the knit remained quite flexible but the fixation of the individual yarns of the knit had a negative influence on the cut resistance of the glove. to avoid this phenomenon dot-coating was chosen to achieve the wanted antislip features of the glove. the binder bemicoat scs appeared to be the most suitable: it adheres well to the knit and the underlying membrane, which gives the possibility to attach the membrane to the knit via the dots. the dot-coated glove shows good antislip properties.  
  
the pe knit of the glove is stained easily; a treatment is recommended to avoid this staining, especially with fish oil. a suitable wetting agent for the pe knit was found, which resulted in a good pick-up of the antistaining agent bemiguard eco (nn). very good results towards (fish) oil repellency are obtained, even after washing.  
  
t 4.3 development of materials with self-repair functions  
three commercial systems suitable for use as self repair materials have been investigated. the first system from bayer materials, showed good self healing with a water column value of 350 cm before damage, 18cm after damage and 54 cm after healing.  
  
the second system arkema, was very good at healing but not suitable for this application. the third system trialled was suprapolix, and issues with coating technique have yet to be overcome.  
  
t4.4 integration of lightweight and flexible materials for buoyancy; inflatable and non-inflatable concepts  
the main objective of task 4.4 was to i) integrate new structures and materials for buoyancy in the work clothing, without reducing work comfort, ii) increase flexibility, and iii) increase moisture and heat transport. these objectives were met by completion of task 4.4 and the tasks within wp3 concept development and prototyping.  
  
a number of essential criteria's for selection of the final buoyancy solution were identified in delivery 2.1 report on market and user screening and delivery 2.4 report on detailed needs and specifications;  
  
- to be accepted and used by the fishermen, the integrated buoyancy solution must provide the desired freedom of movement and work comfort (related to e.g. fit, flexibility, weight, volume, ventilation and insulation).  
- regular lifejackets are considered bulky and uncomfortable.  
- the new product is first and foremost work clothing. focus on out-of-water properties as well as in-water properties.  
- the new solution should be a product for sudden and unexpected man-over-board situations.  
- the buoyancy solution should preferably offer more than 50n of buoyancy.  
  
several iterations and redesigns have been made throughout the project, both on sketch and prototype level. the buoyancy properties of the work clothing depend on the total clothing concept; material properties, size, fit, and weight affect the in-water performance and the end-user acceptance of the product. to be able to evaluate the concepts, prototypes of the different solutions were developed in cooperation with wp 3 concept development and prototyping. four prototypes were presented at m18; three utilizing inherent buoyancy foam and one with inflatable buoyancy. based on end-user feedback and identified requirements, the inflatable concept was selected for the final solution. this concept had the potential of a higher level of buoyancy without reducing work comfort and provided less insulation, which is considered one of the main downsides of today's state-of-the-art work clothing with inherent buoyancy foam. after this decision was made, isp developed and tested a large number of inflatable bladder designs. the final design (d4.4 demonstrator buoyancy solution) consists of a single chambered inflatable bladder which is integrated in the upper front of the bib. this buoyancy distribution ensures self-righting properties which is not present in todays stat-of-the-art work clothing with inherent buoyancy. the safe@sea bib and jacket has the following in-water properties:  
  
- 80 n of inflatable buoyancy  
- 8 cm freeboard (wearing the jacket)  
- 60â° trunk angle (inclined backwards)  
- self-righting properties (less than5 sec)  
  
t 4.5 integration of shock absorber materials for head protection and gloves  
originally (in annex i) the task t.4.5 was named as integration of shock absorbing materials for head protection. safe@sea 18 month ga meeting stated that a specific subtask for gloves should be established and anchored into task 4.5. this anchoring was mainly because of two reasons: 1) project did not contain a specific subtask for gloves, 2) b.huhta, a glove manufacturer in safe@sea, expressed an interest to become also a manufacturer for headgear being developed. task t4.5 was renamed as head protection and gloves containing subtasks t.4.5.1 head protection and t4.5.2 gloves.  
  
t4.5.1 head protection  
the overall goal of the project regarding head protection was to increase the use of head protection gear on fishing vessels and due this generate reduction of head injuries among fishermen. project aimed to answer this by developing new type of soft, flexible and comfortable protective headgear by integrating smart shock absorber materials into ordinary headgear.  
  
the directive 89/391 eec (safety and health at work) guarantees minimum safety and health requirements. the guidance and regulations on implementation of this directive for merchant shipping and fishing vessels (for instance uk marine guidance notes, uk merchant shipping notices) list only two relevant ppe standards for head and scalp protection, en 397:1995 'industrial safety helmets' and en 812: 2002 'industrial bump caps. today, based on the risk assessment of the fishing vessel the use of an industrial safety helmet or an industrial bump cap can be mandatory in certain work activities. when thinking of task specific hazards of fishermen both standards leave a number of essential features unaddressed because they are both written more for an industrial context. also the interviews among fishermen showed that stiff and rigid helmets and bump caps are in many cases regarded very uncomfortable to wear. this means that in work activities where the use of ppe headgear is not mandatory, the fishermen are typically working either bareheaded or with a headgear having protection only for weather conditions.  
  
studies on relevant standards and the prioritized lists of the user requirements defined in wp2 (ref. delivery d2.4) set the guidelines for the further development and creation of new headgear concepts. the impact protection requirement of en 812 is rather low. in spite of this en 812 was selected to base the further development on, because en 812 enables flexible headgear concepts. the future commercialization of the headgear will also be much easier if the headgear can be approved according an existing ppe standard already listed in guidance and regulations of using protective headgear onboard. the impact protection level to be reached was of course set higher than en 812 requires. stab protection requirement was kept as it is in en 812. an important long-term goal was also to pursue standardization authorities to start preparing a new ppe standard.  
  
based on a state-of-the-art search seven (7) commercial smart material brands were selected for preliminary testing: poron xrd, sun mate foams, confor foams, dow corning deflexion (tp-range and s-range structures), d3o, zoombang and np gel / agel. these materials represented two main groups of flexible smart materials. one group contains polymer materials having both shear thickening (dilatant) and viscoelastic properties. they are flexible and comfortable in normal use but on impact they momentarily stiffen and absorb the impact energy. another group of materials are specialty foams having gel-like properties while maintaining some of the desirable properties of ordinary foam. typically they are urethane based open-celled viscoelastic "memory" foams having high energy-absorption characteristics.  
  
impact tests for evaluation and comparison of smart materials and structures were made using tut's in-house test arrangements of en 812 industrial bump caps and en 13158 protective jackets, body and shoulder protectors for equestrian use. based on test results poron xrd and dow corning deflexion brands were selected for prototyping. optimal densities and layer thicknesses for both these materials were selected based on further impact and stab protection testing on all available xrd and deflexion material grades.  
  
smart impact protection material layers alone (in appropriate thicknesses) are not capable of producing stab protection required in en 812. beside searching and testing commercial material structures tut made several different approaches to create flexible, textile based multilayer structures for stab protection. multilayer laminates were made by utilizing different high tech fabrics and nonwoven felts (aramid, uhmwpe, high tenacity polypropylene), fabrics reinforced by needle punching bicomponent pe-pp staple fibres on them etc. a multilayer pp-fabric laminate fulfilling set requirements was developed, but this was not selected to final prototypes because a suitable, already a commercial textile laminates from italian tessiltoschi s.r.l. was found based on material searches.  
  
headgear concept design and all prototypes were made by gze within wp3. prototypes were developed based on three (3) concept designs 1) rigid, 2) semi-rigid and 3) flexible. field tests among norwegian fishermen were arranged by sintef during summer 2012. in general all fishermen liked to maintain the option of all 3 designs, also a different summer and winter versions gained complements: "we all work in cold and harsh environments, so there is a need for different versions. a regular cap would be nice during summer time â an insulated hat is more useful in the winter time". final prototypes were made by gze based on feedback from fishermen.  
  
en 812 in-house tests on the combination of protective material layers showed that the impact protection performance of the headgear is â¨3 times higher than en 812 requirements. b.huhta oy will continue the commercialization process of the headgear.  
  
t 4.6 fabric construction for full scale prototypes  
a priority list of the most important features of the fabric was set in the beginning of the project.  
  
1. waterproofness  
2. cleanability/washability (preferably 40 â°c)  
3. durability (should exceed existing products)  
4. work comfort (better to be solved through the design, and also by the right underwear clothing, a 3 layer system package. an intangible expression, involving the combination of breathability, fit, weight, stretch etc).  
  
a square meter weight of 350 g/m2 was set as a maximum and to aim for during development process. based on this input, two types of weaves presented for the clothing system. they were chosen due to high tear strength and abrasion resistance in combination with low weight. one alternative was polyamide, 228 dtex, with plain construction and the other one was polyester, 550 dtex, also plain construction. the polyamide weave was better regarding the properties of interest, but has a higher price. they were both suitable to be coated on the outside and the inside but it was decided to coat them on the outside.  
  
it was decided to go for a polyurethane coating system instead of pvc coating that is used today. weave was produced and sent to centexbel and sintef for continuing the development of coatings with different features like self-healing, dirt repellence etc. in month 18 the most promising material technologies for further development and prototyping was selected. based on the trials at centexbel, the polyamide weave was selected.  
  
a weave with ripstop construction that provides high tear strength was also developed in the project and tested by swerea. it was aimed for exposed areas like end of sleeves, knees and elbows. it was later decided not to use this material in the final prototypes.  
  
manufacturing for full scale intermediate prototypes was performed just after month 23 with the coating system developed and tested in lab by centexbel. up scaling of a new coating system gave as expected some new experiences and challenges during the manufacturing of the first batch. the new developed water-based polyurethane was traditional knife coated on the weave. in later batches for full scale final prototypes the plain construction was shifted to a twill construction to give the final fabric a softer handle. different machine settings were tested in order to solve problems with cracks in the coating. this solved the cracking but added a strip problem instead. discussions with one of the chemical suppliers are still ongoing. investigation to use other base fabrics in order to solve the adhesion problem will continue. one alternative is to test fabrics with airtexturized yarns, not to use calendaring as a pre-process. some elaboration on the pretreatment of the fabrics regarding water repellency has been performed.  
  
fov are working for commercialization and are convinced that an excellent fabric will be delivered to hh. discussion will continue confidential on both hh and fov's requests.  
  
wp5 integration technologies for ict solutions  
  
the overall objective of wp5 was to design and integrate selected state of the art ict solutions that support alerting, localization and possible emergency stop systems in clothing. the goal was further to ensure robustness to the highly corrosive wet and salt environment whilst enabling integration of personal safety functions without compromising garment comfort for end-users.  
  
system design, investigation and selection of ict solution components  
  
the final wp5 system consists of three main components; the personal worn units, the radio link between user and boat, the central and stationary alarm unit. the units to be worn by the user counts an emergency light unit (el) and a man over board unit (mob) that is both activated as they are immersed into water. each unit is an integrated part of the garment, however if the units are not properly attached it will cause major discomfort in the use of the work clothes.  
  
given that the units are robust enough to be washed, they should not be detached except for yearly maintenance or unless the mob unit battery needs replacing or if the el unit needs to be replaced with a new unit. it is essential for the end-user that there is a very high degree of freedom to move and work while wearing the equipment. due to this, there has been a high focus on the methods and materials used for the integration and encapsulation of the units.  
  
between the user and vessel there is a radio link that transmits the alarm data in case of an accident.  
  
the radio link has to fulfill certain standards that ensure the range of operation and that also avoids the user from being too highly exposed to electromagnetic radiation as the antenna is located very closely to the body.  
  
a stationary alarm unit, a receiver, is located on the boat and is paired with each mob unit worn onboard the vessel. as the alarm reaches the receiver, the current gps location is logged and can be used in a search and rescue situation.  
  
the safe@sea mob system is based on the commercially available deltaalarm mob\_system from deltaalarm and subcomponents from this system, in addition to new components that have been developed. the el unit is based on the commercially available emergency light type lnk-lj-02a2-uml1.  
  
design of co ...

# PROSPIE

Project Acronym: PROSPIE

programme & topic: FP7-NMP NMP-2008-4.0-9

Most frequent returning words in objectives:

* ('system', 19)
* ('sensors', 11)
* ('temperature', 10)
* ('results', 8)
* ('prospie', 7)
* ('protective', 7)
* ('core', 7)
* ('project', 5)
* ('clothing', 5)
* ('model', 5)
* ('specifications', 5)
* ('development', 4)
* ('body', 4)
* ('work', 4)
* ('production', 4)
* ('protocols', 4)
* ('skin', 4)
* ('humidity', 4)
* ('conditions', 3)
* ('training', 3)
* ('salts', 3)
* ('subjects', 3)
* ('identification', 3)
* ('objectives', 2)

project context and objectives:   
  
 the objectives of prospie are summarised below.   
  
 o1.1: development of dynamic cooling system   
 o1.2: integration of a dynamic cooling system in personal protective equipment (ppe)   
 o2.1: integration of sensors in ppe to measure essential body parameters and the environmental (work place) conditions   
 o3.1: development of a decision algorithm to establish the physical condition of the wearer of ppe during work   
 o4.1: the development of integral safe ppe   
 o5.1: industrial production of the prospie protective clothing   
 o5.2: test protocols for safe use of the protective clothing   
 o6.1: establishing the performance of the ppe under real conditions: technological performance and acceptance by the users   
 o7.1: standardisation of the ppe (textile aspects, electronic protocols, decision algorithm)   
 o7.2: training module for the proper use, care and maintenance of this advanced ppe   
  
 project results:   
  
 the project started with development of salts that can absorb moisture and simultaneously generate only a minimal amount of heat (wp1). in this way more sweat can evaporate from the skin and cooling can be enhanced.   
  
 also, a warning system was developed triggered by temperature and humidity sensors in the underwear and outerwear (wp2). a successful demonstration was given by ifak in december 2010. the system is wireless: the information was shown on a standalone laptop.   
  
 the criteria for generating the warning are investigated in wp3. a literature review revealed that core temperatures above 38.5 â°c should generate the alarm, both for the user and a central warning. in order to come with acceptable solutions, the core temperature had to be estimated using non-invasive methods. therefore, an experiment was conducted in 21 subjects under a variety of ambient conditions in two different garments in which core temperature was estimated on the basis of temperature and humidity sensors at the skin and in the garments. the analysis revealed that skin temperature alone was not sufficient to estimate core temperature accurately. however, using multiple linear regression, a standard error of about 0.3 â°c can be achieved in combination with the fiala model. the results are encouraging and show that core temperature may be estimated indirectly.   
  
 a start is made to integrate the results of wp 1, 2 and 3. an industrial designer will play a major role and the focus will be on human factors aspects. in the mean time, the first separate parts (cooling and warning system) have been shown on several occasions including the ppe conference in brussels organised by euratex en the smart textile salon in ghent, organised by the eu project systex. positive feedback has been received and interest is expressed by many researchers and companies.   
  
 in numbers the progress in work in defined as per schedule in the enclosed pdf.   
  
 the results can be summarised as follows:   
  
 - identification of a combination of salts that absorp moisture when relative humidity is high without generating much heat (patent applied for).   
 - identification of thresholds (in core temperature) above which humans cannot sustain work: 38.5 â°c.   
 - improvement of a thermophysiological model (fiala model), in particular the anthropometric background and the link with sensors on the human skin.   
 - encapsulation of the salts in microcapsules.   
 - construction of a wireless warning system based on temperature and humidity sensors. the system was demonstrated in december 2010.   
 - a description of the industries that may benefit from a cooling / warning system, in particular the road construction and metal melting industry.   
 - validation and determination of the accuracy of the sensors intended for use in the prospie system.   
 - a study in which the relation between core temperature and other sensors in underwear and protective system is investigated for 21 subjects.   
 - first validation of the model to the measurements in the subjects: the models seem to predict with a standard error of the mean of about 0.3 â°c.   
 - first description of how the integrated system may be constructed.   
  
 potential impact:   
  
 the exploitable results were identified during and after the exploitation strategy seminar (ess) and the background / foreground knowledge contribution was taken as a start-point for the quantification of profit share for the identified exploitable results.   
  
 14 main exploitable results were identified:   
  
 exploitable results:   
  
 1. safety criteria and predictors, lu, tno, functional specifications   
 2. design specifications for protective clothing, bel-confect, design specifications taking into account   
 3. protective clothing technical specifications, tno, technical specifications (strength, etc.)   
 4. prospie protective clothing production protocol, tno, production guidelines and protocols   
 5. dynamic model therm. physical worker, ergonsim, simulation and modelling   
 6. body sensors, tno, body sensors   
 7. workplace sensors, humanikin, environmental sensors   
 8. dynamic cooling system, capzo, tno, empa, lti, dynamic cooling of body under thermal stress   
 9. smart system, tno, humanikin, intelligent system   
 10. integrated prospie system, all that worked on it, the complete system   
 11. data transfer safety systems, ifak, data transferring system (9sw)   
 12. validated demo of integrated prospie system for various applications, tno, lu, important for demonstration and marketing   
 13. industrial training protocols and courses, tno, both for production and use   
 14. academic training materials, lu, important to disseminate to students for future identification.   
  
 most partners indicated that result 10, the integrated prospie systems, was the most attractive system to bring to the market. it contains the combined expertise. belconfect is the partner that will make the final product, while pakaita will deliver the instrumented underwear.   
  
 project website: http://www.prospie.eu

# ACCEPT

Project Acronym: ACCEPT

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('cleaning', 128)
* ('project', 31)
* ('devices', 24)
* ('textiles', 21)
* ('technology', 21)
* ('year', 21)
* ('surfaces', 19)
* ('impact', 19)
* ('sector', 18)
* ('textile', 18)
* ('solvent', 17)
* ('parts', 16)
* ('implants', 15)
* ('lco2/scco', 15)
* ('performance', 15)
* ('garment', 14)
* ('leathers', 13)
* ('fine', 13)
* ('metal', 13)
* ('units', 13)
* ('dpco', 13)
* ('machines', 13)
* ('solvents', 12)
* ('water', 12)

the cleaning of pliable (textiles and leathers) and hard surfaces (medical devices, medical implants and fine metal parts) requires solvents to remove dirt and soils before the materials can be (re-)used in their final applications. these solvents can be organic solvents (halogena-ted and non-halogenated hydrocarbons) for a-polar soils or water with chemicals for polar soils. each type of liquid has environmental and hygienic drawbacks. the cleaning and hygienic efficiency of these solvents and aqueous systems is not sufficient as small amounts of residual cleaning agents and/or soil impair the quality of the cleaned surface.   
  
 the (non) halogenated hydrocarbon and aqueous systems can be replaced by liquid or supercritical carbon dioxide (co2), i.e. lco2/scco2 as a clean, hygienic and environmentally sound solvent. lco2/scco2 has shortcomings at present and needs improvement of its cleaning performance and quantification of its disinfecting / sterilisation potential. project accept investigates the use of lco2/scco2 with respect to cleaning effectiveness and antimicrobial activity on pliable and hard surfaces (textiles, leathers, medical devices, implants and fine metal parts). the research continues earlier laboratory and pilot research, but will expand this to full scale industrial sized lco2/scco2 cleaning units. in order to remove surface residuals, a co2-precision cleaning step is required for fine parts. the earlier research will be extended to other hygienically demanding materials to be cleaned. the project further improves lco2 for cleaning and hygienic quality of these materials. this will lead to replacement of (non) halogenated hydrocarbon solvents such as hazardous perc and toxic trichloroethene. lco2/scco2 is non-toxic, non-flammable, has disinfecting/sterilising properties, is produced as an off-gas in almost pure form in the oil refining and ammonia production, causes no ground-water contamination and is very sustainable and environmental friendly.   
  
 project context and objectives:   
  
 the purpose of the project was a further improvement and promotion of a competitive, sustainable, antimicrobial, environmentally sound, safe and labour friendly co2 based cleaning technology to replace conventional hydrocarbon and halogenated organic solvents. project accept had three general goals that are translated into eight specific objectives, which are:   
  
 1. to improve the lco2/scco2 cleaning performance till 90-110% compared to hydrocarbon and chlorinated organic solvent cleaning of textiles, leathers, medical devices, implants and fine metal parts, as part of work package one (wp1), wp2 and wp5;   
 2. to reduce the greying / re-deposition of removed soils suspended in the lco2 by 30% (wp5, wp6);   
 3. to improve the hygienic quality (disinfection of heat sensitive implants) by 40%, the reduction of chemical residues on pliable and hard surfaces by 70% and maintenance of medical devices with oil during lco2/scco2 processing (wp3, wp4);   
 4. to improve product coating (improved water and soil repellence coatings) and impregnation (leathers) of pliable surfaces by lco2/scco2 based applications by 25% (wp7);   
 5. to quantify the reduced ecological impact of lco2/scco2 as compared to water and hydrocarbon solvents (wp7, wp8);   
 6. to design an improved full-scale lco2/scco2 unit and its integration in the production chain (wp9);   
 7. to transfer and disseminate the results of lco2 cleaning technology to 500 small and medium sized enterprises (smes) through website visits, i-course material, a text book and training manuals (wp10);   
 8. to manage the project according to state-of-the-art methodologies with no cost overruns and accomplishment of its targeted objectives (wp11).   
  
 it was the first goal of accept to achieve an improved lco2 cleaning performance of pliable (textiles and leathers) and hard surfaces (medical devices, implants and fine metal parts) and reach a higher end-product quality, a more secure low temperature disinfection and lower economic costs, at full-scale level. the end result is expected to be better than that of the current conventional cleaning technologies.   
  
 it was the second goal of the project to plan and design the integration of the lco2 technology into the total processing chain for future on-site implementation in the european union (eu) cleaning sector.   
  
 it was the third goal to disseminate the research findings on an eu scale, to develop training materials suitable for the eu cleaning sectors and to assist the introduction of the lco2 technology in actual practice. accept has 11 wps, namely:   
 - baseline;   
 - lco2 detergents;   
 - hygiene / germicides;   
 - hygiene / no-residuals;   
 - improvement of cleaning performance;   
 - filtration during cleaning step;   
 - coating and impregnation;   
 - spin-off applications;   
 - up-scaling methodologies;   
 - information transfer and dissemination of project finding;   
 - project management.   
  
 it is the ultimate goal of the project to promote and introduce a competitive, sustainable, hygienic, environmentally and labour friendly cleaning technology to replace hazardous (non) halogenated hydrocarbon solvents and use the lco2/scco2 as a final cleaning step (after aqueous cleaning). the good cleaning efficiency of lco2/scco2 with respect to soils and its disinfection ability makes it a highly innovative procedure that has the potential to replace many conventional cleaning processes in the near future. no other solvent has this potential.   
  
 the new cleaning equipment will provide better working conditions as solvent fumes are prevented. the lco2/scco2 cleaning systems bear no risk of soil- and groundwater contamination as well as no air pollution. these new developed cleaning systems are cleaner than the current conventional cleaning systems.   
  
 the exploitation of the developed technologies is outlined in the exploitation plan. the future eu economic gains from the project accept are estimated at 12 - 21 % per year for the growth of the respective sector of cleaning companies and sustain an otherwise threatened eu cleaning sector with annual sales of eur 21 billion. calculations showed that lco2/scco2 replacement costs are similar to organic solvent units, but will allow offering superior product quality.   
  
 the consortium of the project consists of six sme participants, two large enterprises (le) participants and three rtd performers from eight european countries.   
  
 the seventh framework programme (fp7) sme1 project accept has achieved its goals and objectives at the end of the project due to a considerable and extra effort in the second half of the project. in total 230.4 person months were spent, which is 29 % more than originally planned.   
  
 the potential impact of the project is sweeping as it could potentially replace numerous hydrocarbon and water-based cleaning systems. the lco2/scco2 cleaning systems have a powerful hygienic effect as these are efficiently inactivating micro-organisms.   
  
 project results:   
  
 hygienic lco2 cleaning   
  
 cleaning of pliable (textiles and leathers) and hard surfaces (medical devices, medical implants and fine metal parts) requires solvents to remove dirt and soils before the materials can be (re-) used in their final applications. it was the purpose of the project to investigate, further improve and promote a competitive, sustainable, hygienic, environmentally and labour friendly co2 based cleaning technology to replace conventional hydrocarbon and halogenated organic solvents. the main project findings are that the currently used (non) halogenated hydrocarbon and aqueous systems can be replaced by dpco2 (liquid co2 or supercritical co2, depending on the chemical nature of the soilings) as a clean, hygienic and environmentally sound solvent. the current project has delivered improved cleaning performance for lco2 cleaning of pliable and hard surfaces.   
  
 lco2 cleaning performance pliable surfaces   
  
 the lco2 cleaning performance for pliable surfaces such as textiles, leathers, suede's and furs at full-scale level has been improved in an electrolux s35 industrial test facility (itf) at the test plant of rtd-performer wfk. adequate mechanical action as one of the parameters for achieving cleaning action can be verified by using rotating drum separator (rds).   
  
 new detergents of coordinator kreussler achieving a better cleaning performance were developed. the new monitor system pcms-97pes/wo for the lco2 textile cleaning performance was developed to receive a better and more exact determination for the removal of soilings and stains on textiles.   
  
 lco2 cleaning performance hard surfaces   
  
 lco2 cleaning performance fine metal parts   
  
 the project demonstrated an adequate dpco2 cleaning performance of hard surfaces at pilot-scale level in 40 l high-pressure co2 autoclave. a selection for cleaning with lco2 (liquid co2) or with scco2 (supercritical co2) for fine metal parts and is possible with this equipment and depends on the chemical nature of the soilings. adequate effects at pilot-scale level have been proven and can easily be up-scaled to full-scale industrial levels.   
  
 lco2 cleaning performance medical devices, medical instruments and implants   
  
 the project clearly showed adequate cleaning and hygiene of medical instruments / devices and implants is possible by lco2 cleaning. sufficient disinfection / sterilisation was demonstrated by a model system with flexible endoscopes: pcds (process challenging devices) were treated in 4 l high-pressure autoclave.   
  
 an industrial full-scale prototype for lco2 cleaning of medical instruments / devices can be produced from the specifications of this 4 l high-pressure autoclave.   
  
 thereafter this lco2 equipment can be integrated in the factory material processing chain of cleaning of medical instruments / devices.   
  
 greying and filtration   
  
 the greying effect of textiles (redeposition of soils during the washing cycle) is an important subject that occurred during cleaning of textiles; it is not a subject for other pliable surfaces such as leathers and suede's.   
  
 the experimental results gained on the analysis of eight different recipient fabrics show that greying occurs to a minor degree in the presence of a detergent in lco2. the worst greying effect was observed for cotton terry cloth that reached a q = 0.72 over 5 treatments. q-values for preferred types of textile to be treated in lco2, i.e. wool (60 a) and silk (70 a), were determined to q = 0.85 respectively q = 0.91. for the average of the analysed 8 different fabrics cleaned in lco2 with detergent clip coo of kreussler greying was q = 0.854, significantly less compared to the treatment in lco2 plus water (q = 0.78).   
  
 taken all together, the experiments demonstrate that textile treatment in lco2 plus water resulted in some minor greying of the textiles. however, this greying is significantly reduced if detergents like clip coo were applied in the treatment. the presence of detergents reduced the greying to negligible levels and improved the simultaneous cleaning performance.   
  
 filtration of the cleaning liquid during washing is not necessary, as the greying effect has been reduced until a negligible level by this research project. so, there's no need for an extension of the high-pressure equipment with an expensive filter.   
  
 lco2 textile cleaning machines such as the electrolux s35 itf are following a different concept from standard dry cleaning machines with filters. the electrolux s35 itf cleans textiles similar to washing machines in a standing baths in which pump- and filter circuits do not exist. the electrolux s35 itf system is cleaning in standing baths, while the cage is rotating with reverse rhythm; the textiles are hit and simultaneously redistributed with the lifters in the cage. this concept avoids the necessity of having a solvent pump. the construction of a lco2 textile cleaning machines in this aspect is easier.   
  
 furthermore, air channels and steam or electrical heated drying including strong fans to transport warm air including air filters to remove fluffs for drying is not necessary. another big advantage is that a lco2 textile cleaning machines need no water-cooling. the average use of cooling-water for a standard 15 kg dry cleaning machine is about 300 litres of water per cycle (the water consumption of a standard dry cleaning machine without cooling water reuse is nearly as much as of a washing machine; these costs of cooling-water are between eur 7.00 to 8.00 per day). this one of the reasons for a lower cost price of lco2 textile cleaning compared to standard dry cleaning with perc or hydrocarbons.   
  
 hygienic cleaning   
  
 pliable surfaces such as textile, leathers, suede's, furs and hard surfaces such as medical devices, medical instruments and implants are significant areas for hygiene / disinfection.   
  
 co2 in its liquid and supercritical state exhibits a well-known broad antimicrobial activity. lco2 is registered as a biocide on annex 1a of the biocide regulation. the benefit of using lco2 as a cleaning fluid with disinfection properties is first the efficiency against germs and the beneficial disinfection can be done without leaving any residue on the textile. for this reason, in dermatological aspects co2 cleaned textiles cannot have a negative impact on human skin per definition. many studies reported the inactivation of bacteria by dense phase co2 (dpco2). also fungi and even bacterial spores are inactivated within 0.25 - 2.1 minutes at usually applied parameters (50 - 80 bars). viruses and spores are inactivated by supercritical co2 treatment of medical devices. current research focuses on the impact of lco2 inactivation towards bacteria of clinical relevance, i.e. pathogenic bacteria like staphylococcus aureus, bacillus cereus, listeria innocua, salmonella salford, proteus vulgaris, legionella dunnifii and pseudomonas aeruginosa. inactivation mechanisms currently investigated are:   
  
 1. decrease of the intracellular ph of the microbes;   
 2. alteration of the cell biomembrane and solubilisation of components;   
 3. solubilisation and degeneration of proteins of the outer cell surface;   
 4. extraction of intracellular substances;   
 5. inactivation by denaturing of intracellular enzymes responsible for metabolism;   
 6. disruption of the biomembrane and the cell wall due to rapid expansion after processing.   
  
 the range of investigation in the experimental study of the antimicrobial activity of dpco2 was broadened for further relevant pathogenic micro-organisms of clinical relevance as well as for the mechanism of microbial inactivation. the full list of tested microbes comprises: escherichia coli, pseudomonas aeruginosa, klebsiella pneumoniae, proteus mirabilis, mycobacterium terrae, staphylococcus aureus, enterococcus faecium, enterococcus hirae, listeria innocua, micrococcus luteus, lactococcus lactis, bacillus subtilis - vegetative cells, bacillus subtilis - spores, bacillus cereus, bacillus atrophaeus (as vegetative cells and as spores), spores of geobacillus stearothermophilus, candida albicans and spores of aspergillus niger.   
  
 the experimental setup was: micro-organisms to be tested in the experimental set-up were mixed with reactivated (heparinised) sheep blood and spread on metal discs that serve as process challenging devices (pcds).   
  
 the pcds were incubated for 15 min in a 0.75 l high-pressure autoclave. experiments with lco2 were conducted at room temperature (20 â°c) and a correlating pressure of approximately 55 bars. experiments with scco2 were conducted at 36 â°c and a correlating pressure of approximately86 bars. the number of replicates was increased to at least n = 3.   
  
 these results demonstrate that scco2 exhibited a higher antimicrobial activity compared to lco2. differences amount to up to five orders of magnitude or even higher, e.g. klebsiella pneumoniae, mycobacterium terrae, lactococcus lactis, candida albicans and aspergillus niger spores. in general the antimicrobial activity of lco2 against gram-negative bacteria tends to be higher compared to gram-positive species. for scco2 treatment the overall results are less regularly regarding the comparison of gram-positive and gram-negative bacteria. for example, lactococcus lactis yielded high reduction factors of 5.6 that are comparable to reduction factors of gram-negative bacteria. within the group of gram-positive bacteria the tested bacillus cereus (vegetative cells) showed the highest susceptibility to lco2 with a reduction factor of 2.6. the least reduction factors have been reported for bacterial spores of bacillus atrophaeus and geobacillus stearothermophilus.   
  
 lco2 as well as scco2 yielded reduction factors of less than 0.29 negligible for practical use.   
  
 dpco2 is suitable for highly sensible goods like food because of the unaltered taste and the non-hazardous character of the agent. since the process is conducted without a significant increase of temperature, it is also applicable for articles that are sensible to elevated temperatures such as medical implants (e.g. heart valves, biomembranes). dpco2 is a suitable medium for a very nice disinfection of hard surfaces at low temperature and without toxic agents.   
  
 taken all together the selected phase status of dense phase co2 has an enormous impact on the inactivation of bacterial and fungal pathogens, with scco2 surpassing lco2 by far for many test species.   
  
 coatings and impregnation   
  
 the difficulties arising from bath processes for impregnation might be overcome by a spray method applicable to textiles and leathers. the installation of a spraying unit integrated in an existing type of a lco2 textile cleaning machines is possible in principle, but linked to larger engineering efforts and comprehensive technical modifications of the high-pressure vessel. the installation must be carried in a way, to enter the pressurised vessel from the top and installing a spraying nozzle, which will spray from top / front down into the falling textiles. during the spraying, the rotation of the drum must only be in a single direction. a difficulty of spray processes arises from the high-pressure conditions inside the lco2 cleaning vessel. the spraying system should have to overcome the counter pressure to spray on textiles within the enclosed environment with an existing pressure of up to 50 bars. the system pressure of spraying systems is usually 5 to 8 bars.   
  
 for the specific application in lco2, this pressure adds to the existing pressure in the chamber. this makes a total pressure of approximately 58 bars that has to be generated.   
  
 another issue using such a system is the regulation of the sprayed fluid volume. visual inspection is not possible and sensing systems require again larger engineering efforts.   
  
 as proposed for the use in bath processes high concentrated usually water based low cure resins, mixed with a low amount of isopropyl alcohol at cold temperature in the cage will be a safe treatment, being more than 20 â°c below flash point in a co2 atmosphere.   
  
 again the other option would be the use of low cure resins mixed in a small amount of cyclic silicones. the experiments affirm that it is possible to achieve in future an efficient coating / impregnation of textiles in lco2, after optimisation of the process.   
  
 cost price   
  
 the costs per kg garment cleaned in lco2 in a lco2 textile cleaning plant with complementary wetcleaning are the lowest of the 3 compared cleaning methods perc, hc (hydrocarbons) and lco2 with wet cleaning: eur 0.72/kg garment. the cost price per kg garment cleaned in perc or in hc in a plant is eur 0.81/kg garment respectively eur 0.77/kg garment. the cost price per kg garment in unit-shops compared to plants is somewhat higher (eur 0.01 - 0.04) due to different scale level with lower production efficiency.   
  
 the above costs can deviate by 10 % (with outlayers of 20 %), mainly driven by internal logistics and not correctly executed procedures such as pre-spotting.   
  
 the collected soil from lco2 textile cleaning is free of any solvent residues and highly concentrated. it can be collected for very low cost and because of the content of oil and skin fat will have a positive input to regain energy by incineration of the halogen free waste from the textile cleaning sector.   
  
 the following conclusions are drawn from the research findings:   
  
 1. textile cleaning with lco2 is most efficient in utility use and disposal of waste.   
 2. the cost price per kg garment cleaned in lco2 is the lowest of three compared cleaning methods: eur 0.68/kg garment (plant) and eur 0.72/kg garment (unit-shop).   
 3. the cost price per kg garment cleaned in perc or in hc are higher than cleaned in lco2: eur 0.78/kg garment respectively 0.76/kg garment in a plant and eur 0.81/kg garment respectively 0.77/kg garment in a unit-shop.   
 4. the costs of lco2 textile cleaning in a plant are 13% lower than of dry cleaning in perc and 11 % lower than of dry cleaning in hydrocarbons (hc).   
 5. the costs of lco2 textile cleaning in a unit-shop are 11 % lower than of dry cleaning in perc and 6 % lower than of dry cleaning in hc (hydrocarbons).   
  
 spin-offs   
  
 compressed, liquefied co2 is assumed to have a big potential as substitute for numerous organic solvents for a large variety of applications. dense phase co2 (dpco2) is non-toxic, non-flammable and sustainable, environmentally sound and cannot cause ground-water contamination. it is not classified as volatile organic compound (voc) as it is a natural atmospheric gas. moreover, dpco2 has a strong disinfecting / sterilising property under respective conditions, is relatively easy to handle with containments below 60 bars and is produced as an off-gas in almost pure form in the oil refining industry, the ammonia production and can easily be produced from the exhaust emissions of conventional power plants.   
  
 dpco2is an effective cleaning agent for non-polar contaminants that can be augmented by addition of detergents and other additives and co-solvents. articles treated in dpco2 do not require a drying step as it is needed by classical solvent systems or water. this offers additional energy savings. after the process the dpco2 can be recovered due to distillation of the liquid with minor energy input, allowing many cycles. dpco2 treatment does not cause shrinkage, surface alteration and abrasion to the great majority of materials and leaves no residue on the cleaned surfaces after the final evaporation. the use of lco2 and/or scco2 as a solvent offers unique opportunities for a broad range of applications.   
  
 deoiling of metal or plastic parts from different kind of industry again will leave the hard surface free of solvent contaminants. the very low surface tension of lco2 will improve the spreading effect on hard surfaces. energy for drying is not necessary, the hard surfaces are cleaned in a gentle way, it is free of water and corrosion problems caused by the cleaning fluid cannot occur in lco2 textile cleaning.   
  
 its extreme low viscosity and the outstanding ability to spread on surfaces gives lco2 the benefit to clean fine capillaries and expensive medical devices removing the contaminant and simultaneously disinfecting the surface of medical instruments. cleaning of medical devices in a water free disinfection process is a proven new application for lco2 cleaning with a high potential for the future.   
  
 fine tubes and capillaries up to now are difficult to clean. with the developed new dpco2 technology there is a chance for efficient cleaned efficient cleaning. potential use for sensitive electronic chips or platines, avoiding thermal stress, can take benefit from residue-free cleaning in dpco2.   
  
 project website address: http://kreussler.com/accept/   
  
 potential impact:   
  
 strategic impact   
  
 impact for the sme participants   
  
 the needs of the individual sme project participants are:   
  
 1. to decrease costs of their processes in order to become more competitive;   
 2. to decrease labour costs by better and shorter cleaning steps;   
 3. to become more sustainable;   
 4. to improve the technology basis of the company;   
 5. to investigate and test the pilot scale technology on-site;   
 6. to integrate the new lco2 technology into their regular processes;   
 7. to maintain the product quality of the cleaning operation using lco2;   
 8. to maintain the hygiene / disinfection / sterilisation of the cleaned materials using lco2;   
 9. to compare individual performance with peers through bench marking;   
 10. to improve the technical knowledge and skills of their employees.   
  
 their current cleaning technologies cannot meet the upcoming eu and national requirements regarding volatile emissions and labour conditions. the rising costs of the cleaning processes are now barely covered by their sales prizes, but will experience a shortfall in the near future thus weakening the entire sector. these needs and economic threats are met by the new comprehensive lco2 technology of the project. this technology cannot be developed and paid for by the individual smes, but requires eu financial support.   
  
 impact at the eu level   
  
 up to now lco2 is not used for the cleaning/disinfection of textiles and leathers, medical devices, implants and fine metal parts, besides the early adopters fred butler, kymi rens, etiquette and amsonic (all participants in the project). the research will have a large impact on the cleaning practices within the eu and strengthen the sme cleaning companies that are able to adopt the environmental friendly lco2 technology.   
  
 impact on textile cleaning sector   
  
 dry cleaning of textiles is conducted in 60 000 eu dry cleaning shops (mostly smes) with an annual turn-over of eur nine billion, employing 150 000 workers and cleaning 1.2 million tonnes of textiles each year, utilising 75 000 cleaning machines and releasing more than 78 000 tonnes of hazardous perc per year into the environment. the german market has 3 000 unit shops employing 17 000 workers cleaning 200 kilotons textiles per year representing 318 million garments. the whole european dry cleaning industry is currently undergoing a major reorganisation with mergers of smaller shops into larger units and an overall slight contraction.   
  
 the replacement of these perc cleaning machines by the lco2 cleaning units generates sales of 7 500 units/year x 150 000 eur/unit = 1 125 000 000 eur per year, assuming a 10 year life of existing units and 100% replacement by lco2. the expected penetration is 25 % thus generating sales of 281 250 000 eur per year.   
  
 the adoption of the lco2 cleaning technology by the sme companies will lessen their impact on the environment and strengthen their position compared to conventional organic solvent cleaners.   
  
 impact on leather treatment sector   
  
 treatment of hides and leathers is conducted in 5000 eu leather treatment companies with an annual turn-over of 3 billion eur, employing 40 000 workers and treating 0.3 million tonnes of leathers each year, utilising 5000 cleaning machines.   
  
 the replacement of these leather cleaning machines by the lco2 cleaning units generates sales of 500 units/year x 150 000 eur/unit = 75 000 000 eur per year, assuming a 10 year life of existing units and 100% replacement by lco2. the expected penetration is 25 % thus generating sales of 19 000 000 eur per year.   
  
 most of the hides and leather treatment companies are medium sized and are strengthened by incorporating the new lco2 technology, as it gives them a competitive advantage over similar companies in developing countries using conventional organic solvent technologies that are harmful to the environment.   
  
 impact on medical devices sector   
  
 the processing of the over 400 000 different types of medical devices and products is highly diverse. all devices and products need sterilisation. as numerous devices are reused, the cleaning and sterilisation will take place several times per device. lco2 treatment can replace conventional heat sterilisation for especially heat labile devices such as flexible endoscopes etc. the potential lco2 cleaning / disinfection / sterilisation market for medical devices and product is estimated at 8000 units in europe, assuming each hospital purchases a unit with a lifetime of 10 years. the annual sales are then 800 units per year x 150 000 eur/unit = 120 000 000 eur per year. as the penetration is estimated at 50%, the expected sales are 60 000 000 eur per year.   
  
 impact on medical implants sector   
  
 the manufacturing and processing of medical implants takes place both in large medical supply companies as well as in smes specialised in providing custom metal and ceramic implants. all implants are subjected to the highest standards for hygiene / cleanliness / sterility. some of the devices are heat labile and cannot be sterilised by steam or ethylene oxides. it is estimated that the heat labile implant manufacturers will require 100 lco2 cleaning units. assuming a lifetime of the units of 10 years, this represents sales of 10 units/year x 150 000 eur/unit = 1 500 000 eur per year. as the heat labile market will accept 50% penetration, the sales are expected at 750 000 eur per year.   
  
 impact on fine metal parts cleaning sector   
  
 the total number of parts cleaning machines using halogenated solvents is 3500 emitting a total of 85 000 tonnes of perc per year. the total number of parts cleaning machines using non halogenated hydrocarbon solvent is 2000. both employ 27 500 workers and generating 5.5 billion in sales for parts cleaning. the expected of lco2 cleaning units to be placed in the sector is 550 units per year x 150 000 eur/unit = 82 500 000 eur per year, assuming a 10 year lifetime per unit and a 100 % penetration. an expected penetration is 25 % thus generating sales of 20 600 000 eur per year. most of the fine metal parts cleaners are companies within in-house cleaning shops. however, a growing number of smes is offering these cleaning services either onsite or at their own facilities. the purchase of a lco2 cleaning unit wood gives them a strong advantage in parts cleaning over conventional in-house solvent cleaning shops. it is estimated that this will generate an additional 5000 workers for the smes.   
  
 impact on the sme cleaning sector   
  
 the rtd needs of the eu sme cleaning sector are largely driven by restrictive legislation. the situation in the eu member states is focused on the phase-out of organic solvent cleaning in favour of more environmental processes such as lco2 cleaning.   
  
 the adaptation of environmental friendly cleaning technologies will be more in line with consumer expectations and will improve the image of the sector, thereby attracting more business. the problems described above occur in each eu country. therefore an eu wide approach for finding and developing alternative cleaning methods is required.   
  
 the sector needs a new, sustainable technology with less environmental and economical risks. without such a new technology, the future eu cleaning market is threatened and in danger of contracting. the availability of the clean lco2 technology eliminates the current organic solvent problems of the sector, namely complicated permitting, high insurance, potential soil and groundwater contamination from leaking tanks, pipes and machines, placement of expensive vapour barriers, installation of expensive enclosed machinery, expensive ventilation provisions, negative health impact (influenced menstrual cycle of women and possible pregnancy effects).   
  
 cleaning sectors in individual countries represented in the project strive for an eu research approach, because of limited national funds and greater research efficiency on an eu scale. the project will strengthen the eu cleaning equipment manufacturing sector as export opportunities will increase. the project will stabilise eu employment because of the availability of the new cleaning technology that reduces health problems for staff. lco2 technology will require more education and training of each employee, creating training employment opportunities. introduction of new technologies will improve the competitiveness of the eu equipment manufacturers and detergent suppliers. this will reduce unemployment and improve working conditions for both skilled and unskilled workers. the eu equipment manufacturing and detergent sector will be strengthened.   
  
 impact on other sectors   
  
 the lco2 technology in this project will have spin-off applications for extraction processes in decaffeination, deteaination, flavour and fragrance extraction, soy meal extraction, olive oil extraction, moto ...

# ACCEPT

Project Acronym: ACCEPT

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('cleaning', 128)
* ('project', 31)
* ('devices', 24)
* ('textiles', 21)
* ('technology', 21)
* ('year', 21)
* ('surfaces', 19)
* ('impact', 19)
* ('sector', 18)
* ('textile', 18)
* ('solvent', 17)
* ('parts', 16)
* ('implants', 15)
* ('lco2/scco', 15)
* ('performance', 15)
* ('garment', 14)
* ('leathers', 13)
* ('fine', 13)
* ('metal', 13)
* ('units', 13)
* ('dpco', 13)
* ('machines', 13)
* ('solvents', 12)
* ('water', 12)

the cleaning of pliable (textiles and leathers) and hard surfaces (medical devices, medical implants and fine metal parts) requires solvents to remove dirt and soils before the materials can be (re-)used in their final applications. these solvents can be organic solvents (halogena-ted and non-halogenated hydrocarbons) for a-polar soils or water with chemicals for polar soils. each type of liquid has environmental and hygienic drawbacks. the cleaning and hygienic efficiency of these solvents and aqueous systems is not sufficient as small amounts of residual cleaning agents and/or soil impair the quality of the cleaned surface.   
  
 the (non) halogenated hydrocarbon and aqueous systems can be replaced by liquid or supercritical carbon dioxide (co2), i.e. lco2/scco2 as a clean, hygienic and environmentally sound solvent. lco2/scco2 has shortcomings at present and needs improvement of its cleaning performance and quantification of its disinfecting / sterilisation potential. project accept investigates the use of lco2/scco2 with respect to cleaning effectiveness and antimicrobial activity on pliable and hard surfaces (textiles, leathers, medical devices, implants and fine metal parts). the research continues earlier laboratory and pilot research, but will expand this to full scale industrial sized lco2/scco2 cleaning units. in order to remove surface residuals, a co2-precision cleaning step is required for fine parts. the earlier research will be extended to other hygienically demanding materials to be cleaned. the project further improves lco2 for cleaning and hygienic quality of these materials. this will lead to replacement of (non) halogenated hydrocarbon solvents such as hazardous perc and toxic trichloroethene. lco2/scco2 is non-toxic, non-flammable, has disinfecting/sterilising properties, is produced as an off-gas in almost pure form in the oil refining and ammonia production, causes no ground-water contamination and is very sustainable and environmental friendly.   
  
 project context and objectives:   
  
 the purpose of the project was a further improvement and promotion of a competitive, sustainable, antimicrobial, environmentally sound, safe and labour friendly co2 based cleaning technology to replace conventional hydrocarbon and halogenated organic solvents. project accept had three general goals that are translated into eight specific objectives, which are:   
  
 1. to improve the lco2/scco2 cleaning performance till 90-110% compared to hydrocarbon and chlorinated organic solvent cleaning of textiles, leathers, medical devices, implants and fine metal parts, as part of work package one (wp1), wp2 and wp5;   
 2. to reduce the greying / re-deposition of removed soils suspended in the lco2 by 30% (wp5, wp6);   
 3. to improve the hygienic quality (disinfection of heat sensitive implants) by 40%, the reduction of chemical residues on pliable and hard surfaces by 70% and maintenance of medical devices with oil during lco2/scco2 processing (wp3, wp4);   
 4. to improve product coating (improved water and soil repellence coatings) and impregnation (leathers) of pliable surfaces by lco2/scco2 based applications by 25% (wp7);   
 5. to quantify the reduced ecological impact of lco2/scco2 as compared to water and hydrocarbon solvents (wp7, wp8);   
 6. to design an improved full-scale lco2/scco2 unit and its integration in the production chain (wp9);   
 7. to transfer and disseminate the results of lco2 cleaning technology to 500 small and medium sized enterprises (smes) through website visits, i-course material, a text book and training manuals (wp10);   
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 - improvement of cleaning performance;   
 - filtration during cleaning step;   
 - coating and impregnation;   
 - spin-off applications;   
 - up-scaling methodologies;   
 - information transfer and dissemination of project finding;   
 - project management.   
  
 it is the ultimate goal of the project to promote and introduce a competitive, sustainable, hygienic, environmentally and labour friendly cleaning technology to replace hazardous (non) halogenated hydrocarbon solvents and use the lco2/scco2 as a final cleaning step (after aqueous cleaning). the good cleaning efficiency of lco2/scco2 with respect to soils and its disinfection ability makes it a highly innovative procedure that has the potential to replace many conventional cleaning processes in the near future. no other solvent has this potential.   
  
 the new cleaning equipment will provide better working conditions as solvent fumes are prevented. the lco2/scco2 cleaning systems bear no risk of soil- and groundwater contamination as well as no air pollution. these new developed cleaning systems are cleaner than the current conventional cleaning systems.   
  
 the exploitation of the developed technologies is outlined in the exploitation plan. the future eu economic gains from the project accept are estimated at 12 - 21 % per year for the growth of the respective sector of cleaning companies and sustain an otherwise threatened eu cleaning sector with annual sales of eur 21 billion. calculations showed that lco2/scco2 replacement costs are similar to organic solvent units, but will allow offering superior product quality.   
  
 the consortium of the project consists of six sme participants, two large enterprises (le) participants and three rtd performers from eight european countries.   
  
 the seventh framework programme (fp7) sme1 project accept has achieved its goals and objectives at the end of the project due to a considerable and extra effort in the second half of the project. in total 230.4 person months were spent, which is 29 % more than originally planned.   
  
 the potential impact of the project is sweeping as it could potentially replace numerous hydrocarbon and water-based cleaning systems. the lco2/scco2 cleaning systems have a powerful hygienic effect as these are efficiently inactivating micro-organisms.   
  
 project results:   
  
 hygienic lco2 cleaning   
  
 cleaning of pliable (textiles and leathers) and hard surfaces (medical devices, medical implants and fine metal parts) requires solvents to remove dirt and soils before the materials can be (re-) used in their final applications. it was the purpose of the project to investigate, further improve and promote a competitive, sustainable, hygienic, environmentally and labour friendly co2 based cleaning technology to replace conventional hydrocarbon and halogenated organic solvents. the main project findings are that the currently used (non) halogenated hydrocarbon and aqueous systems can be replaced by dpco2 (liquid co2 or supercritical co2, depending on the chemical nature of the soilings) as a clean, hygienic and environmentally sound solvent. the current project has delivered improved cleaning performance for lco2 cleaning of pliable and hard surfaces.   
  
 lco2 cleaning performance pliable surfaces   
  
 the lco2 cleaning performance for pliable surfaces such as textiles, leathers, suede's and furs at full-scale level has been improved in an electrolux s35 industrial test facility (itf) at the test plant of rtd-performer wfk. adequate mechanical action as one of the parameters for achieving cleaning action can be verified by using rotating drum separator (rds).   
  
 new detergents of coordinator kreussler achieving a better cleaning performance were developed. the new monitor system pcms-97pes/wo for the lco2 textile cleaning performance was developed to receive a better and more exact determination for the removal of soilings and stains on textiles.   
  
 lco2 cleaning performance hard surfaces   
  
 lco2 cleaning performance fine metal parts   
  
 the project demonstrated an adequate dpco2 cleaning performance of hard surfaces at pilot-scale level in 40 l high-pressure co2 autoclave. a selection for cleaning with lco2 (liquid co2) or with scco2 (supercritical co2) for fine metal parts and is possible with this equipment and depends on the chemical nature of the soilings. adequate effects at pilot-scale level have been proven and can easily be up-scaled to full-scale industrial levels.   
  
 lco2 cleaning performance medical devices, medical instruments and implants   
  
 the project clearly showed adequate cleaning and hygiene of medical instruments / devices and implants is possible by lco2 cleaning. sufficient disinfection / sterilisation was demonstrated by a model system with flexible endoscopes: pcds (process challenging devices) were treated in 4 l high-pressure autoclave.   
  
 an industrial full-scale prototype for lco2 cleaning of medical instruments / devices can be produced from the specifications of this 4 l high-pressure autoclave.   
  
 thereafter this lco2 equipment can be integrated in the factory material processing chain of cleaning of medical instruments / devices.   
  
 greying and filtration   
  
 the greying effect of textiles (redeposition of soils during the washing cycle) is an important subject that occurred during cleaning of textiles; it is not a subject for other pliable surfaces such as leathers and suede's.   
  
 the experimental results gained on the analysis of eight different recipient fabrics show that greying occurs to a minor degree in the presence of a detergent in lco2. the worst greying effect was observed for cotton terry cloth that reached a q = 0.72 over 5 treatments. q-values for preferred types of textile to be treated in lco2, i.e. wool (60 a) and silk (70 a), were determined to q = 0.85 respectively q = 0.91. for the average of the analysed 8 different fabrics cleaned in lco2 with detergent clip coo of kreussler greying was q = 0.854, significantly less compared to the treatment in lco2 plus water (q = 0.78).   
  
 taken all together, the experiments demonstrate that textile treatment in lco2 plus water resulted in some minor greying of the textiles. however, this greying is significantly reduced if detergents like clip coo were applied in the treatment. the presence of detergents reduced the greying to negligible levels and improved the simultaneous cleaning performance.   
  
 filtration of the cleaning liquid during washing is not necessary, as the greying effect has been reduced until a negligible level by this research project. so, there's no need for an extension of the high-pressure equipment with an expensive filter.   
  
 lco2 textile cleaning machines such as the electrolux s35 itf are following a different concept from standard dry cleaning machines with filters. the electrolux s35 itf cleans textiles similar to washing machines in a standing baths in which pump- and filter circuits do not exist. the electrolux s35 itf system is cleaning in standing baths, while the cage is rotating with reverse rhythm; the textiles are hit and simultaneously redistributed with the lifters in the cage. this concept avoids the necessity of having a solvent pump. the construction of a lco2 textile cleaning machines in this aspect is easier.   
  
 furthermore, air channels and steam or electrical heated drying including strong fans to transport warm air including air filters to remove fluffs for drying is not necessary. another big advantage is that a lco2 textile cleaning machines need no water-cooling. the average use of cooling-water for a standard 15 kg dry cleaning machine is about 300 litres of water per cycle (the water consumption of a standard dry cleaning machine without cooling water reuse is nearly as much as of a washing machine; these costs of cooling-water are between eur 7.00 to 8.00 per day). this one of the reasons for a lower cost price of lco2 textile cleaning compared to standard dry cleaning with perc or hydrocarbons.   
  
 hygienic cleaning   
  
 pliable surfaces such as textile, leathers, suede's, furs and hard surfaces such as medical devices, medical instruments and implants are significant areas for hygiene / disinfection.   
  
 co2 in its liquid and supercritical state exhibits a well-known broad antimicrobial activity. lco2 is registered as a biocide on annex 1a of the biocide regulation. the benefit of using lco2 as a cleaning fluid with disinfection properties is first the efficiency against germs and the beneficial disinfection can be done without leaving any residue on the textile. for this reason, in dermatological aspects co2 cleaned textiles cannot have a negative impact on human skin per definition. many studies reported the inactivation of bacteria by dense phase co2 (dpco2). also fungi and even bacterial spores are inactivated within 0.25 - 2.1 minutes at usually applied parameters (50 - 80 bars). viruses and spores are inactivated by supercritical co2 treatment of medical devices. current research focuses on the impact of lco2 inactivation towards bacteria of clinical relevance, i.e. pathogenic bacteria like staphylococcus aureus, bacillus cereus, listeria innocua, salmonella salford, proteus vulgaris, legionella dunnifii and pseudomonas aeruginosa. inactivation mechanisms currently investigated are:   
  
 1. decrease of the intracellular ph of the microbes;   
 2. alteration of the cell biomembrane and solubilisation of components;   
 3. solubilisation and degeneration of proteins of the outer cell surface;   
 4. extraction of intracellular substances;   
 5. inactivation by denaturing of intracellular enzymes responsible for metabolism;   
 6. disruption of the biomembrane and the cell wall due to rapid expansion after processing.   
  
 the range of investigation in the experimental study of the antimicrobial activity of dpco2 was broadened for further relevant pathogenic micro-organisms of clinical relevance as well as for the mechanism of microbial inactivation. the full list of tested microbes comprises: escherichia coli, pseudomonas aeruginosa, klebsiella pneumoniae, proteus mirabilis, mycobacterium terrae, staphylococcus aureus, enterococcus faecium, enterococcus hirae, listeria innocua, micrococcus luteus, lactococcus lactis, bacillus subtilis - vegetative cells, bacillus subtilis - spores, bacillus cereus, bacillus atrophaeus (as vegetative cells and as spores), spores of geobacillus stearothermophilus, candida albicans and spores of aspergillus niger.   
  
 the experimental setup was: micro-organisms to be tested in the experimental set-up were mixed with reactivated (heparinised) sheep blood and spread on metal discs that serve as process challenging devices (pcds).   
  
 the pcds were incubated for 15 min in a 0.75 l high-pressure autoclave. experiments with lco2 were conducted at room temperature (20 â°c) and a correlating pressure of approximately 55 bars. experiments with scco2 were conducted at 36 â°c and a correlating pressure of approximately86 bars. the number of replicates was increased to at least n = 3.   
  
 these results demonstrate that scco2 exhibited a higher antimicrobial activity compared to lco2. differences amount to up to five orders of magnitude or even higher, e.g. klebsiella pneumoniae, mycobacterium terrae, lactococcus lactis, candida albicans and aspergillus niger spores. in general the antimicrobial activity of lco2 against gram-negative bacteria tends to be higher compared to gram-positive species. for scco2 treatment the overall results are less regularly regarding the comparison of gram-positive and gram-negative bacteria. for example, lactococcus lactis yielded high reduction factors of 5.6 that are comparable to reduction factors of gram-negative bacteria. within the group of gram-positive bacteria the tested bacillus cereus (vegetative cells) showed the highest susceptibility to lco2 with a reduction factor of 2.6. the least reduction factors have been reported for bacterial spores of bacillus atrophaeus and geobacillus stearothermophilus.   
  
 lco2 as well as scco2 yielded reduction factors of less than 0.29 negligible for practical use.   
  
 dpco2 is suitable for highly sensible goods like food because of the unaltered taste and the non-hazardous character of the agent. since the process is conducted without a significant increase of temperature, it is also applicable for articles that are sensible to elevated temperatures such as medical implants (e.g. heart valves, biomembranes). dpco2 is a suitable medium for a very nice disinfection of hard surfaces at low temperature and without toxic agents.   
  
 taken all together the selected phase status of dense phase co2 has an enormous impact on the inactivation of bacterial and fungal pathogens, with scco2 surpassing lco2 by far for many test species.   
  
 coatings and impregnation   
  
 the difficulties arising from bath processes for impregnation might be overcome by a spray method applicable to textiles and leathers. the installation of a spraying unit integrated in an existing type of a lco2 textile cleaning machines is possible in principle, but linked to larger engineering efforts and comprehensive technical modifications of the high-pressure vessel. the installation must be carried in a way, to enter the pressurised vessel from the top and installing a spraying nozzle, which will spray from top / front down into the falling textiles. during the spraying, the rotation of the drum must only be in a single direction. a difficulty of spray processes arises from the high-pressure conditions inside the lco2 cleaning vessel. the spraying system should have to overcome the counter pressure to spray on textiles within the enclosed environment with an existing pressure of up to 50 bars. the system pressure of spraying systems is usually 5 to 8 bars.   
  
 for the specific application in lco2, this pressure adds to the existing pressure in the chamber. this makes a total pressure of approximately 58 bars that has to be generated.   
  
 another issue using such a system is the regulation of the sprayed fluid volume. visual inspection is not possible and sensing systems require again larger engineering efforts.   
  
 as proposed for the use in bath processes high concentrated usually water based low cure resins, mixed with a low amount of isopropyl alcohol at cold temperature in the cage will be a safe treatment, being more than 20 â°c below flash point in a co2 atmosphere.   
  
 again the other option would be the use of low cure resins mixed in a small amount of cyclic silicones. the experiments affirm that it is possible to achieve in future an efficient coating / impregnation of textiles in lco2, after optimisation of the process.   
  
 cost price   
  
 the costs per kg garment cleaned in lco2 in a lco2 textile cleaning plant with complementary wetcleaning are the lowest of the 3 compared cleaning methods perc, hc (hydrocarbons) and lco2 with wet cleaning: eur 0.72/kg garment. the cost price per kg garment cleaned in perc or in hc in a plant is eur 0.81/kg garment respectively eur 0.77/kg garment. the cost price per kg garment in unit-shops compared to plants is somewhat higher (eur 0.01 - 0.04) due to different scale level with lower production efficiency.   
  
 the above costs can deviate by 10 % (with outlayers of 20 %), mainly driven by internal logistics and not correctly executed procedures such as pre-spotting.   
  
 the collected soil from lco2 textile cleaning is free of any solvent residues and highly concentrated. it can be collected for very low cost and because of the content of oil and skin fat will have a positive input to regain energy by incineration of the halogen free waste from the textile cleaning sector.   
  
 the following conclusions are drawn from the research findings:   
  
 1. textile cleaning with lco2 is most efficient in utility use and disposal of waste.   
 2. the cost price per kg garment cleaned in lco2 is the lowest of three compared cleaning methods: eur 0.68/kg garment (plant) and eur 0.72/kg garment (unit-shop).   
 3. the cost price per kg garment cleaned in perc or in hc are higher than cleaned in lco2: eur 0.78/kg garment respectively 0.76/kg garment in a plant and eur 0.81/kg garment respectively 0.77/kg garment in a unit-shop.   
 4. the costs of lco2 textile cleaning in a plant are 13% lower than of dry cleaning in perc and 11 % lower than of dry cleaning in hydrocarbons (hc).   
 5. the costs of lco2 textile cleaning in a unit-shop are 11 % lower than of dry cleaning in perc and 6 % lower than of dry cleaning in hc (hydrocarbons).   
  
 spin-offs   
  
 compressed, liquefied co2 is assumed to have a big potential as substitute for numerous organic solvents for a large variety of applications. dense phase co2 (dpco2) is non-toxic, non-flammable and sustainable, environmentally sound and cannot cause ground-water contamination. it is not classified as volatile organic compound (voc) as it is a natural atmospheric gas. moreover, dpco2 has a strong disinfecting / sterilising property under respective conditions, is relatively easy to handle with containments below 60 bars and is produced as an off-gas in almost pure form in the oil refining industry, the ammonia production and can easily be produced from the exhaust emissions of conventional power plants.   
  
 dpco2is an effective cleaning agent for non-polar contaminants that can be augmented by addition of detergents and other additives and co-solvents. articles treated in dpco2 do not require a drying step as it is needed by classical solvent systems or water. this offers additional energy savings. after the process the dpco2 can be recovered due to distillation of the liquid with minor energy input, allowing many cycles. dpco2 treatment does not cause shrinkage, surface alteration and abrasion to the great majority of materials and leaves no residue on the cleaned surfaces after the final evaporation. the use of lco2 and/or scco2 as a solvent offers unique opportunities for a broad range of applications.   
  
 deoiling of metal or plastic parts from different kind of industry again will leave the hard surface free of solvent contaminants. the very low surface tension of lco2 will improve the spreading effect on hard surfaces. energy for drying is not necessary, the hard surfaces are cleaned in a gentle way, it is free of water and corrosion problems caused by the cleaning fluid cannot occur in lco2 textile cleaning.   
  
 its extreme low viscosity and the outstanding ability to spread on surfaces gives lco2 the benefit to clean fine capillaries and expensive medical devices removing the contaminant and simultaneously disinfecting the surface of medical instruments. cleaning of medical devices in a water free disinfection process is a proven new application for lco2 cleaning with a high potential for the future.   
  
 fine tubes and capillaries up to now are difficult to clean. with the developed new dpco2 technology there is a chance for efficient cleaned efficient cleaning. potential use for sensitive electronic chips or platines, avoiding thermal stress, can take benefit from residue-free cleaning in dpco2.   
  
 project website address: http://kreussler.com/accept/   
  
 potential impact:   
  
 strategic impact   
  
 impact for the sme participants   
  
 the needs of the individual sme project participants are:   
  
 1. to decrease costs of their processes in order to become more competitive;   
 2. to decrease labour costs by better and shorter cleaning steps;   
 3. to become more sustainable;   
 4. to improve the technology basis of the company;   
 5. to investigate and test the pilot scale technology on-site;   
 6. to integrate the new lco2 technology into their regular processes;   
 7. to maintain the product quality of the cleaning operation using lco2;   
 8. to maintain the hygiene / disinfection / sterilisation of the cleaned materials using lco2;   
 9. to compare individual performance with peers through bench marking;   
 10. to improve the technical knowledge and skills of their employees.   
  
 their current cleaning technologies cannot meet the upcoming eu and national requirements regarding volatile emissions and labour conditions. the rising costs of the cleaning processes are now barely covered by their sales prizes, but will experience a shortfall in the near future thus weakening the entire sector. these needs and economic threats are met by the new comprehensive lco2 technology of the project. this technology cannot be developed and paid for by the individual smes, but requires eu financial support.   
  
 impact at the eu level   
  
 up to now lco2 is not used for the cleaning/disinfection of textiles and leathers, medical devices, implants and fine metal parts, besides the early adopters fred butler, kymi rens, etiquette and amsonic (all participants in the project). the research will have a large impact on the cleaning practices within the eu and strengthen the sme cleaning companies that are able to adopt the environmental friendly lco2 technology.   
  
 impact on textile cleaning sector   
  
 dry cleaning of textiles is conducted in 60 000 eu dry cleaning shops (mostly smes) with an annual turn-over of eur nine billion, employing 150 000 workers and cleaning 1.2 million tonnes of textiles each year, utilising 75 000 cleaning machines and releasing more than 78 000 tonnes of hazardous perc per year into the environment. the german market has 3 000 unit shops employing 17 000 workers cleaning 200 kilotons textiles per year representing 318 million garments. the whole european dry cleaning industry is currently undergoing a major reorganisation with mergers of smaller shops into larger units and an overall slight contraction.   
  
 the replacement of these perc cleaning machines by the lco2 cleaning units generates sales of 7 500 units/year x 150 000 eur/unit = 1 125 000 000 eur per year, assuming a 10 year life of existing units and 100% replacement by lco2. the expected penetration is 25 % thus generating sales of 281 250 000 eur per year.   
  
 the adoption of the lco2 cleaning technology by the sme companies will lessen their impact on the environment and strengthen their position compared to conventional organic solvent cleaners.   
  
 impact on leather treatment sector   
  
 treatment of hides and leathers is conducted in 5000 eu leather treatment companies with an annual turn-over of 3 billion eur, employing 40 000 workers and treating 0.3 million tonnes of leathers each year, utilising 5000 cleaning machines.   
  
 the replacement of these leather cleaning machines by the lco2 cleaning units generates sales of 500 units/year x 150 000 eur/unit = 75 000 000 eur per year, assuming a 10 year life of existing units and 100% replacement by lco2. the expected penetration is 25 % thus generating sales of 19 000 000 eur per year.   
  
 most of the hides and leather treatment companies are medium sized and are strengthened by incorporating the new lco2 technology, as it gives them a competitive advantage over similar companies in developing countries using conventional organic solvent technologies that are harmful to the environment.   
  
 impact on medical devices sector   
  
 the processing of the over 400 000 different types of medical devices and products is highly diverse. all devices and products need sterilisation. as numerous devices are reused, the cleaning and sterilisation will take place several times per device. lco2 treatment can replace conventional heat sterilisation for especially heat labile devices such as flexible endoscopes etc. the potential lco2 cleaning / disinfection / sterilisation market for medical devices and product is estimated at 8000 units in europe, assuming each hospital purchases a unit with a lifetime of 10 years. the annual sales are then 800 units per year x 150 000 eur/unit = 120 000 000 eur per year. as the penetration is estimated at 50%, the expected sales are 60 000 000 eur per year.   
  
 impact on medical implants sector   
  
 the manufacturing and processing of medical implants takes place both in large medical supply companies as well as in smes specialised in providing custom metal and ceramic implants. all implants are subjected to the highest standards for hygiene / cleanliness / sterility. some of the devices are heat labile and cannot be sterilised by steam or ethylene oxides. it is estimated that the heat labile implant manufacturers will require 100 lco2 cleaning units. assuming a lifetime of the units of 10 years, this represents sales of 10 units/year x 150 000 eur/unit = 1 500 000 eur per year. as the heat labile market will accept 50% penetration, the sales are expected at 750 000 eur per year.   
  
 impact on fine metal parts cleaning sector   
  
 the total number of parts cleaning machines using halogenated solvents is 3500 emitting a total of 85 000 tonnes of perc per year. the total number of parts cleaning machines using non halogenated hydrocarbon solvent is 2000. both employ 27 500 workers and generating 5.5 billion in sales for parts cleaning. the expected of lco2 cleaning units to be placed in the sector is 550 units per year x 150 000 eur/unit = 82 500 000 eur per year, assuming a 10 year lifetime per unit and a 100 % penetration. an expected penetration is 25 % thus generating sales of 20 600 000 eur per year. most of the fine metal parts cleaners are companies within in-house cleaning shops. however, a growing number of smes is offering these cleaning services either onsite or at their own facilities. the purchase of a lco2 cleaning unit wood gives them a strong advantage in parts cleaning over conventional in-house solvent cleaning shops. it is estimated that this will generate an additional 5000 workers for the smes.   
  
 impact on the sme cleaning sector   
  
 the rtd needs of the eu sme cleaning sector are largely driven by restrictive legislation. the situation in the eu member states is focused on the phase-out of organic solvent cleaning in favour of more environmental processes such as lco2 cleaning.   
  
 the adaptation of environmental friendly cleaning technologies will be more in line with consumer expectations and will improve the image of the sector, thereby attracting more business. the problems described above occur in each eu country. therefore an eu wide approach for finding and developing alternative cleaning methods is required.   
  
 the sector needs a new, sustainable technology with less environmental and economical risks. without such a new technology, the future eu cleaning market is threatened and in danger of contracting. the availability of the clean lco2 technology eliminates the current organic solvent problems of the sector, namely complicated permitting, high insurance, potential soil and groundwater contamination from leaking tanks, pipes and machines, placement of expensive vapour barriers, installation of expensive enclosed machinery, expensive ventilation provisions, negative health impact (influenced menstrual cycle of women and possible pregnancy effects).   
  
 cleaning sectors in individual countries represented in the project strive for an eu research approach, because of limited national funds and greater research efficiency on an eu scale. the project will strengthen the eu cleaning equipment manufacturing sector as export opportunities will increase. the project will stabilise eu employment because of the availability of the new cleaning technology that reduces health problems for staff. lco2 technology will require more education and training of each employee, creating training employment opportunities. introduction of new technologies will improve the competitiveness of the eu equipment manufacturers and detergent suppliers. this will reduce unemployment and improve working conditions for both skilled and unskilled workers. the eu equipment manufacturing and detergent sector will be strengthened.   
  
 impact on other sectors   
  
 the lco2 technology in this project will have spin-off applications for extraction processes in decaffeination, deteaination, flavour and fragrance extraction, soy meal extraction, olive oil extraction, moto ...

# STAYCOOL

Project Acronym: STAYCOOL

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('heat', 40)
* ('staycool', 32)
* ('system', 32)
* ('fire', 23)
* ('project', 18)
* ('time', 17)
* ('exchanger', 13)
* ('market', 13)
* ('firefighters', 12)
* ('body', 12)
* ('garment', 10)
* ('control', 9)
* ('equipment', 9)
* ('product', 9)
* ('stress', 8)
* ('temperature', 8)
* ('water', 8)
* ('endurance', 8)
* ('weight', 8)
* ('number', 8)
* ('conference', 8)
* ('fires', 7)
* ('clothing', 7)
* ('power', 7)

executive summary  
  
currently, time spent attending to a fire is limited by thermal stress (surpassing the 39 â°c body-temperature limit) experienced by the firefighter, and not by the amount of breathing air that is available. control of wild fires can require firefighters to operate in areas of high radiant heat (from burning vegetation) for prolonged periods of time, and an effective means of personal cooling will improve their effectiveness, and may save lives as heat exhaustion will be delayed and may even be eliminated.  
  
the staycool personal cooling system is a lightweight mobile active-cooling device adequate for preventing thermal stress on human users, keeping constant heat-extraction temperature within a comfortable range and avoiding the effect of cool spots.  
  
the staycool system regulates body temperature through a set of patches attached to a garment in contact with skin (likely through a thermal barrier such as some type of clothing). these patches are attached to a secondary heat exchanger cooled by water that removes the heat extracted from the body. the coolant circuit transfers this heat to the primary heat exchanger, where it is finally sent to the environment by evaporative effect.  
  
features of the developed staycool personal cooling system include:  
  
1. a lightweight and reusable cooling garment with high heat extraction;  
2. lightweight, compact (< 5 litres) evaporative heat exchanger unit with potential to expel 260 w in laboratory conditions;  
3. programmable control system for the management of the different elements of staycool, to maximise endurance and minimise system weight;  
4. endurance of the system (> 1 hour) solely limited by size of water tank (1 litre);  
5. system is driven by body heat, so power source is only required for low-voltage pump, fan and control system;  
6. quick-disconnect pipe connections;  
7. total weight of the system < 5kg;  
8. applicability of low-cost, high-volume manufacturing processes;  
9. applicability to other occupations requiring personal cooling;  
10. low unit cost price.  
  
in summary, staycool personal cooling system has the potential to significantly increase the time attending to the fire by the firefighter and so reduce the time to put out the fire or to attempt a rescue, and consequently reduce damage to property and potential loss of life to the public or the firefighter. it is specially designed for extreme high-temperature environments where heavy, highly insulating personal protective equipment (ppe) and clothing are required.  
  
although the initial application of the staycool product is the firefighting market, which imposes very specific use requirements, it is foreseen that after further development iterations the product will be adapted to other applications requiring low weight, mobile and smart thermal-stress control.  
  
project context and objectives  
  
there are about 500 000 professional fire fighters in the european union (eu). when called to fight fires they can be exposed to high levels of heat stress, which results in decreased physical performance and even heat exhaustion. if a firefighter succumbs to heat exhaustion he requires rescuing and this then exposes other firefighters and the public to increased risk. in order to reduce the risk of heat stress, the firefighters are limited with regard to the time they can attend to the fire, which increases the number of firefighters needed to fight a fire, and this reduces efficiency and introduces complication into the communications between the crews fighting the fire.  
  
the staycool project has developed and prototyped a novel system for cooling the body that is lightweight, has low energy consumption and so can be worn for prolonged periods of time. wearing the staycool system will reduce the wearer's core temperature and allow firefighters to stay at the fire for greater periods of time, and so improve the efficiency of fighting the fire, extinguishing the fire quicker and reducing risk of loss of life and damage to property.  
  
the staycool concept is a new innovative personal cooling system, which is lighter in weight and has greater endurance than existing commercially available systems, while offering significant cooling power and keeping a low price. it consists of a garment incorporating 'cooling pads' that are connected to a compact low-energy heat exchanger that mimics sweating. the principle of the system is that it will by-pass the barrier to sweat evaporation created by the personal protective clothing and allow 'sweating' from a biomimetic surface outside of the clothing. this is to provide heat loss comparable to that from a bare torso but in a package that does not interfere with the activities the user has to execute.  
  
the staycool partnership is ideally placed to develop and exploit this technology, having expertise in protective clothing design and manufacture, physiological and human factors testing, mathematical and thermodynamic modelling, access to rapid prototyping and manufacture facilities, and the ability to design for manufacture to ensure the staycool system can be fully exploited.  
  
the staycool system is primarily aimed at a launch market for firefighters but there are a number of applications where humans need to work in high ambient temperatures. additional markets for this technology and associated products include industrial plant operators, miners, underground maintenance, nuclear decommissioning, general policing in hot climates, policing in protective equipment and for use in extreme sports.  
  
the staycool product will provide the following benefits for the target user.  
  
1. better working conditions due to the low mass of the new system. the weight of the heat-pipe garment is much less than a liquid circulating vest as only a few millilitres of water are required inside the heat pipe to transfer heat to the outside of the clothing.  
  
2. more efficient than other vests due to enhanced cooling capacity. good body contact providing high heat-extraction capacity compared to liquid-circulating vests.  
  
3. useful endurance. as the energy for evaporation comes from the heat of the body and a low mass of water has to be pumped to transfer this heat, power requirements will be modest.  
  
4. comfort. the water within the heat pipe is kept at a low pressure so it does not need to boil to start the heat-pipe cycle, until skin temperature has risen to a level where cooling is required and the pad will be close to skin temperature (i.e. there will be no uncomfortable cold spots).  
  
the staycool project aims include several scientific and technological objectives.  
  
scientific objectives  
  
1. to investigate into wicking and evaporation effects from complex surfaces due to their importance in all the phenomena involved.  
  
technological objectives  
  
1. to develop and manufacture flexible heat pipes  
  
2. to develop a novel, light heat exchanger, garment and laboratory prototype featuring the following characteristics: cooling power > 250 w; mass of heat exchanger and garment < 4.5 kg; heat-exchanger volume < 1 litre, excluding water reservoir; endurance > 1 hour, evaporation of water.  
  
3. to maximise cooling power of the heat exchanger within volume constraints by increasing surface to volume ratio. different wicks bonded to cooling fins will be compared in order to select the optimal method of satisfying ratio of area to volume.  
  
4. to develop a control algorithm and sensors to maximise endurance to > 1 hour and minimise system weight.  
  
5. to gather performance and ergonomic data on the laboratory-prototype garments evidenced in a controlled laboratory trial.  
  
6. to deliver laboratory prototypes, capable of being manufactured within final use constraints: cooling power 250 w; achievable fire fighting certification.  
  
7. to demonstrate system effectiveness during field trials with real fire.  
  
project results  
  
the actual developments obtained for each result after the execution of the staycool project have been the following.  
  
1. a model of evaporative and wicking behaviour that provides reasonable predictions of surface temperatures and evaporative heat loss, used as a design tool to examine the main parameters for controlling evaporation in the design of heat-pipe patches and the primary heat exchanger.  
  
2. construction and testing of the laboratory evaporative heat exchanger, proving the concept of the evaporative effect for the project purposes and used as the base for volunteer trials.  
  
3. a control unit has been designed and built to manage the performance of the heat exchanger, including fan, pump temperature sensors and display screen, as used for volunteer trials.  
  
4. a pre-production prototype of the staycool system has been produced, integrating components of improved designs after feedback from volunteer trials (heat-pipe path, heat exchanger and control unit). the following list provides the main features and specifications, which are pretty close to targets:  
(a) lightweight and reusable cooling garment with high heat extraction;  
(b) lightweight, compact (< 5 litres) evaporative heat-exchanger unit with potential to expel 260 w in laboratory conditions;  
(c) programmable control system for the management of the different elements of staycool, to maximise endurance and minimise system weight;  
(d) endurance of the system (> 1 hour) solely limited by size of water tank (1 litre);  
(e) system is driven by body heat, so power source is only required for low-voltage pump, fan and control system;  
(f) quick disconnect pipe connections;  
(g) total weight of the system < 5kg;  
(h) applicability of low cost, high volume manufacturing processes;  
(i) applicability to other occupations requiring personal cooling;  
(j) low unit cost price.  
  
5. the staycool integrated cooling system (cooling vest and primary heat exchanger) has been tested with fire brigades under training fires. firemen who participated in the cooling-garment trial provided useful and positive comments on the staycool cooling garment:  
(a) the hpg was effective in reducing local skin temperature, improving whole-body thermal comfort, and reducing whole-body and torso heat sensation, although some individuals may perceive the hpg cooling to be âtoo intenseâ;  
(b) the cooling garment could be used as part of a routine to cool the firemen exiting a fire fighting operation, to reduce the risk of heat stress as well as to reduce the recovery time prior to the resumption of operational duties;  
(c) the man-portable cooling garment system could be used for forest fires and road accidents.%%potential impact%%impact on eu society  
  
there are a number of benefits to the eu that will be provided by the staycool project and these include:  
  
1. displacement of non-eu products. one of the additional benefits to the eu is that the sales in europe and also the rest of the world will be at the expense of other suppliers of competing systems, which currently are from outside europe (mainly usa but also australia). this project will increase the competitiveness of the eu in this new and growing market.  
  
2. reduced cost of fire damage. if the firefighters can spend more time fighting the fire (because of the reduction in physiological stress) then fires can be put out quicker and so less damage would be sustained. this would be particularly true for fighting forest fires in southern europe.  
  
3. reduced time off work due to heat stress. the staycool system will reduce the number of occurrences of heat illness and so reduce the time lost by keeping the body core temperature below a tolerable level and below a limit where damage occurs. this also helps the fire services to maintain their high standards of employee care and help meet health and safety standards for working in hot environments.  
4. more efficient use of fire resources. by potentially increasing the time that a firefighter can be at the fire scene by using the staycool system, the rostering of the firefighters can be made more efficient. this will allow more time to fight more fires or provide additional time within the firefighters schedule to maintain currency on other equipment or undertake more training.  
  
impact on participants  
  
the most evident benefit for participants resides in accessing a niche market with an innovative product and a production cost of < 250 eur/unit, within firefighter-market budgetary expectations.  
  
a first estimation of the global firefighting market is described here. fire services around europe are made up of a mixture of professional, part-time and volunteer firefighters. different studies show that the relative proportions of these different classes of firefighter by country across the world are nearly constant. extrapolating these figures, there is a population of approximately 500 000 professional firefighters across europe (there are more than 100 000 in germany, france and poland alone) and, potentially, significantly more than 2 650 000 worldwide. extrapolating the figures from the ctif statistics to take into account significant countries not included in the figures such as spain, the uk, india, china and italy, it can be estimated that a worldwide figure of 4 000 000 firefighters can be used for impact modelling purposes.  
  
in general, the fire service market is a fairly static market that tends to renew equipment in a cyclical manner as and when either new products become available that provide a performance or cost improvement, or the useful life of a piece of equipment comes to an end. the firefighting market is seen as fairly traditional in terms of the equipment and procurement processes it uses, as they tend to be state-funded and therefore have to comply with government procurement processes. the market is also fairly fragmented, as in many countries it is left to the individual fire brigades to procure equipment, and purchasing at a national level is seldom seen. this increases the complexity of the sales task but does give the opportunity for new, niche products to penetrate a number of the smaller, more forward-thinking brigades first. even though the fire services are seen as traditional they are also typically open to evaluate new equipment and tend to be early adopters of new technology. examples of this are thermal-imaging cameras, network communication systems and personal identification systems.  
  
in future (beyond the frame of the staycool project), the resulting product could be adapted for other specialised applications, thus increasing the number of potential users. these applications consist of the following.  
1. industrial   
there are a number of industrial processes that require human intervention in extremely hot environments or wearing high levels of ppe (e.g. glass manufacture, steel processing, chemical plants, nuclear decommissioning). there are also industries that require working in hot environments as part of the day-to-day tasks and where ppe is required. examples of these are mining and underground tunnel maintenance. the staycool system could extend the time that workers are exposed to these environments without causing physiological damage and so increase productivity or reduce the time to carry out tasks.  
  
2. policing  
there are two areas of police work where staycool would improve effectiveness. the first is in public order operations. anytime large numbers of people are brought together (e.g. sporting events, demonstrations), there is a risk of anti-social and even violent behaviour. police personnel are equipped with ppe to protect them from violence aimed at them. however, this ppe is highly insulating and relatively impermeable to sweat loss resulting in a risk of a heat-related illness. also, terrorist threats in the current world political climate create the requirement for police to operate in a contaminated environment wearing high levels of ppe. the heat stress in these situations is exacerbated for example in southern european countries in the summer. staycool would provide cooling to the police officer and allow a longer time on duty, thereby assisting in continuity of operation and contact with the public and increasing the success of the mission.  
  
3. extreme sports  
 body cooling prior and potentially during some sporting events can increase performance. sports that would benefit could include motor sports, marathon running and long-distance cycling. the staycool system would provide a method of either cooling the body whilst carrying out the activity or ensuring the body does not overheat during the warm-up for an event, and so increase performance and competitiveness.  
  
dissemination activities  
  
several partners have attended different dissemination events where the prepared communication materials such as project brochures and presentations have been distributed.   
  
relevant events where staycool has been present  
  
1. conference: 'numerical simulation of heat pipes in the staycool project' presented at workshop on industrial problems (26 october, 2012) the university of santiago de compostella on the 26 october 2012.  
2. conference: textile international forum and exhibition 2012 & 3rd asian protective clothing conference. location: ntuh international convention centre, taipei. 26-27 september 2012.  
3. conference: euratex 7th annual public conference: 29-30 march 2012, brussels. the conference specifically supported dissemination of the following eu-funded projects.  
4. trade fair: a+a safety, 'security and health at workâ, international trade fair with congress, dã¼sseldorf, germany, october 2011  
5. trade fair: techtextil exhibition in frankfurt, international trade fair for technical textiles and nonwoven, june 2011.  
  
a project brochure about project aims, needs to fulfil, strategy, and expected benefits to users was distributed among the partners in order to be used in every conference or trade fair they attended.  
  
the coordinator steve kay (nwt) was asked to produce a piece on staycool for publication in âpolymeric protective technical textiles' 2011, conference proceedings.  
  
intense activity has been carried out by the rdt performers to show technology developments to smes. much of this activity has been conducted in devoted meetings, some of it carried out after or before the consortium meetings (to save project resources), but some also took place by teleconference or special visits.  
  
exploitation of results  
the staycool project foreground exploitation strategy is constructed under the following pillars:  
1. to identify key user groups who have influence in their own regions;  
2. to work with key user groups to test and trial the product to ensure the end product is what the market needs;  
3. to develop product champions throughout key european markets.  
the consortium has performed a market search identifying market needs, target customers, market segment, competitors, and swot. a strategic approach for investments, commercial activity and an implementation schedule has been developed. the business plan has estimated pricing for the final equipment and a sales forecast. different options for public and private funding mechanisms for future investments have been evaluated.  
the staycool results are outstanding, but despite significant advances the consortium recognises that further development is required to fully commercialise this product. it is the intention of the smeâs to retain the foreground intellectual property (ip) as 'trade secret' know-how. the advances that have resulted include the following.  
  
1. significant enhancements in effectiveness/efficiency of heat-pipe patches. the project has succeeded in increasing performance from 25 to 65 w per patch, where the original 25 w patches are protected by qinetiqâs background ip, united kingdom patent application number: gb1006620.7 entitled flexible heat pipe structure for body cooling, dated 21 april 2010.  
2. a prototype primary heat exchanger with a unique multi-plate construction and integrated coolant-pipe configuration.  
3. the background ip protection held by qinetiq provides enforceable protection, which protects these developments through the development stages. the consortium needs to have a financial figure from qinetiq to use it, but it is very difficult to quote nowadays given that the factors that would influence a financial figure ,including exclusivity, volume and selling price, are still undefined.  
  
the sme partners have worked well together through the project. to make the advances necessary we propose to apply for a demonstration activity.  
   
project website: http://www.staycooleu.com/

# ATLANTIS

Project Acronym: ATLANTIS

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('milestone', 14)
* ('water', 12)
* ('system', 11)
* ('ballast', 9)
* ('treatment', 9)
* ('systems', 8)
* ('textile', 8)
* ('si-bas', 7)
* ('flow', 7)
* ('organisms', 6)
* ('ships', 6)
* ('biocidal', 6)
* ('mâ³/hr', 6)
* ('atlantis', 5)
* ('project', 5)
* ('need', 5)
* ('technology', 5)
* ('substances', 5)
* ('marine', 4)
* ('species', 4)
* ('world', 4)
* ('cost', 4)
* ('convention', 4)
* ('target', 4)

atlantis is a two year project, funded by the european commission (ec)'s seventh framework programme (fp7) within the 'research for small to medium-sized enterprises (smes)' scheme. the atlantis consortium is made up of a team of five organisations who have been selected on the basis of their expertise in fields that are complimentary to the development work.   
  
this summary highlights the projects scope and progress made by consortium partners during the first reporting period   
  
the need  
  
ship's ballast water contains a variety of living organisms, some of which survive transit. when ballast water is discharged, these invasive marine organisms can thrive in their new environments. the environment's natural habitat can be threatened and native species can be preyed upon. the economy and livelihood of local communities dependent upon the invaded area's biodiversity can be threatened.  
  
the introduction of invasive marine organisms into new environments has been identified as the fourth largest threat to the world's oceans. the cost of controlling invasive species and repairing the damage caused in 2008 to the european union (eu) was estimated to be between eur 9.6 to eur 12.7 billion. the estimated global cost is much higher at eur 80 billion annually.  
  
with 80 % of the world's commodities being transported by sea, there is an environmental and commercial need to develop an effective solution for the dispersal of untreated ballast water.  
  
to facilitate the global prevention of invasive marine species, the imo adopted the international convention for the control and management of ship's ballast water and sediment. this convention requires ships to install ballast water treatment (bwt) systems and to employ best practises in managing ballast water treatment.  
  
from 2016, all new ships will require bwt and all existing ships will have a further five years to retrofit a bwt system. in september 2009, six bwt systems met the requirements of the imo's approval procedures. several different approaches to these treatments have been used including ultraviolet (uv) technology, deoxygenation and the use of active substances. these first generation systems due to various limitations have sold 23 units globally. limitations found on current bwt systems include:  
  
- capital outlay for current bwt systems is too high;  
- the storage and handling of dangerous chemicals;  
- ineffective removal of target organisms;  
- size of the bwt system can be too large for retrofitting existing ships;  
- some of these systems require trained staff to operate them;  
- all these bwt systems deploy several methods of treatments to achieve sufficient cleaning.  
  
furthermore, the shipping industry is concerned that existing bwt systems are only designed to meet these new imo regulations and do not consider the needs of the end-user. flag administrators in the interests of their own shipping industries are delaying ratification of the convention until further development of bwt technology. the limitations of existing bwt technology are not only failing to meet the requirement of the shipping industry but are also delaying international action to prevent damage caused by invasive species.  
  
the solution  
  
the atlantis project proposes to research and develop the first bwt technology to use functional textiles in a treatment bed as a delivery platform for multiple biocidal active substances (bas). this bwt system will efficiently target and incapacitate a full spectrum of marine organisms < 50 âµm. there is an increasing belief that the use of active substances will become a condition to comply with the convention due to other methods being less effective.  
  
there is a risk that active substances in ballast water may still be toxic at the time of discharge. to solve this issue, bas's will be covalently bonded to non-woven textiles creating a functional textile which will act as a contact-biocide delivery platform. the bas's tethered by a chemical bond will present functional biocidal groups which can lethally interact with microorganisms without risking the release of active substances into the water.  
  
to meet the market's need for a cost effective bwt system, an enabling platform technology (alexium's reactive surface treatment (rst) process) has been identified to create the biocidal functionalised textile solution. to enable the use of the rst process, a number of technological breakthroughs need to be overcome.   
  
scientific objectives  
  
our scientific objectives are set to measure our progress and success in the applied research of the project. these include:  
  
- to determine synthetic pathways and reaction conditions for 5 - 10 si-bas's (milestone 1);  
- to determine the biocidal efficacy in terms of lc90 and minimum contact time of the si-bas's compounds against imo regulations (milestone 1);  
- to determine and optimise mw power and exposure time to facilitate grafting of si-bas's (milestone 3);  
- to access the stability and durability of the si-bas's activated textiles in saline water (salinity range 3-32 psu) under flow conditions of 50 mâ³/hr over a 12 month period (milestone 2);  
- to demonstrate the efficacy of the benchtop biocidal textile treatment bed system against target organisms (g8) at a flow rate of 2.5 mâ³/hr over a 6 month test period (milestone 4);  
- to demonstrate efficacy of the pilot-scale system in achieving water quality to meet imo d2 standards at a flow of up to 50 mâ³/hr (milestone 5).  
  
technical objectives  
  
our technological objectives outline the developments we need to achieve in order to deliver our prototype ballast water treatment system. these are:  
  
- to create a range of 5 - 10 si-bas's that are able to form hypervalent silicon compounds which are to be used with the alexium rst grafting mechanisms (milestone 1);  
- 3 - 5 si-bas's textile finishing microemulsion matrixes with droplet sizes 20 - 100 nm (milestone 2);  
- to specify 3 - 10 nonwoven materials suitable for application in bwt bed system (milestone 2 and 3);  
- to design and construct one to three textile treatment bed configurations providing the required biocide contact time versus flow parameters as determined by computational fluid dynamics (cfd) analysis (milestone 2 and 3);  
- to construct a bench top test platform with a flow capacity of 2.5 mâ³/hr (milestone 4);  
- to achieve a pilot scale (1 - 50 kgs) manufacture of the si-bas's textile finishing matrix formulation (milestone 4);  
- to design and construct a pilot-scale prototype biocidal textile treatment bed system with a footprint of 0.5 - 2.0 mâ² capable of operating with a system flow capacity of 25 - 50 mâ³/hr (milestone 5);  
- produce a pilot-scale test facility capable of providing flow capacity of 25-50 mâ³/hr and to accommodate a textile treatment bed of 0.5 - 2.0 mâ² with a target cost of eur 20 per 1000 mâ³ treated (milestone 5).  
  
expected impact of the project  
  
the dispersion of untreated ballast water from ships today represents the fourth largest threat to the world's oceans. the main driver behind the 2016 legislation is as a direct result of environmental and ecological concerns. furthermore, the ec has a political obligation to ensure that the global enforceable imo legislation is complied with across the eu. equally, it has to represent the eu on the world stage and police all nine eu nations who operate their bwt in the eu region.  
  
the atlantis product will have lower capital costs, reduced operating costs and will be easier to retrofit to existing ships. the atlantis bwt system will satisfy the needs of the shipping industry by supplying a product that will enable them to continue trading whilst complying with the new legislation.   
  
project website: http://www.projectatlantis.eu/index.php

# NATEX

Project Acronym: NATEX

programme & topic: FP7-NMP NMP-2007-4.0-2

Most frequent returning words in objectives:

* ('fibres', 16)
* ('properties', 13)
* ('resins', 9)
* ('fabrics', 7)
* ('fibre', 7)
* ('biocomposites', 6)
* ('project', 5)
* ('development', 5)
* ('surface', 5)
* ('developed', 5)
* ('composites', 5)
* ('polymers', 5)
* ('textiles', 4)
* ('modification', 4)
* ('yarns', 4)
* ('resin', 4)
* ('processing', 4)
* ('compression', 4)
* ('results', 4)
* ('parts', 3)
* ('thermoset', 3)
* ('textile', 3)
* ('techniques', 3)
* ('methods', 3)

project context and objectives:   
  
 natex is focussed on the development of aligned textiles from natural fibres suitable for use as high strength reinforcing fabrics to produce structural composite parts using bio and oil based thermoplastic and thermoset resins. this includes the use of orientated woven natural fibres in bio-derived thermoplastics and thermosets, to produce high-tech products with high added value from entirely renewable resources.   
  
 the main innovations in natex project are:   
  
 1. modification of the fibre surface to obtain the desired interface properties when combined with the polymer matrix   
 2. new spinning process to reduce the yarns' twisting during the textile manufacturing process, increasing the fibre volume fraction and the wetting of the fibres. this is going to increase the mechanical properties of the yarns.   
 3. new weaving techniques are being developed to improve impregnation and to obtain innovative three-dimensional (3d) textiles   
 4. new commingling and film stacking is being developed for thermoplastic composites, for improving the permeability of the composite and to obtain well mingled yarns.   
  
 besides, a large range of resin processing methods will be adapted to suit them to the characteristics of the modified fibres, such as vacuum bagging, vacuum consolidation, compression moulding, continuous compression moulding, infusion and resin transfer moulding.   
  
 basic research on joining technologies as hot welding over natural fibre composites will be also performed.   
  
 project results:   
  
 since the beginning of the project, an important effort has been focussed in the development and modification of natural fibres. as a result, the relationship between fibre processing, fibre defects and fibre properties has been determined. additionally, the modification of surface properties of natural fibres in order to improve interfacial characteristics with both thermoplastic and thermosetting polymers has been performed showing good potential for better compatibility with hydrophobic polymers.   
  
 for the development of natural fibre based textile performs suitable for biocomposites, diverse configurations by using the most suitable spinning systems have been obtained leading to different twisting angles and mechanical properties of the yarns. moreover, blends of natural fibres with both petroleum-based and bio-based thermoplastic fibres have been developed and characterised with good results. 2d and 3d fabrics from natural fibres and blends of thermoplastic and natural fibres have also been successfully prepared and characterised.   
  
 regarding the adaptation of thermoplastic and thermoset polymers to improve their compatibility with natural fibres, sheets obtained from modified petroleum-based and bio-based thermoplastic resins with different additives have featured better extrusion processability, leading to higher dimensional stability, less defects, better aesthetics and higher outputs. moreover, better mechanical properties and adhesion to natural fabrics have been observed compared to raw polymers. in the case of thermosetting resins, the addition of suitable additives have shown improved adhesion of unsaturated polyester resins to natural fabrics, leading to higher mechanical properties. the processing of unsaturated polyester resins and natural fabrics by different methods such as resin transfer moulding (rtm) and infusion has been carried out with good impregnation properties and surface finishing. renewable thermosetting furan resins have shown a performance closed to that of phenolic resins. furthermore, a specific furan resin has been found ideal for prepreg applications.   
  
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 potential impact:   
  
 with respect to the final applications of the project, different case studies have been selected to be developed from natural fabrics and both thermoplastic and thermosetting resins. requirements for these parts have been established and currently work is focussed on the development of first prototypes. good preliminary results have been obtained from the shipbuilding and transport system case studies showing a good prospect for the development of biocomposites from polymers reinforced with natural fibres.   
  
 the expected final results are that aligned natural fibres with improved properties will be combined with thermoplastics and thermosets, increasing the mechanical properties of biocomposites and introducing them in structural applications in different sectors such as transport, energy, agricultural machinery and shipbuilding.   
  
 considering the importance of the final application sectors, the versatility of use of the fabrics in conventional processes, and the nowadays limitations on the use of natural fibres in composites, an important replacement of the currently used traditional textiles and non-textiles by natural textiles is expected in the composites sector since these natural reinforcements are kept at competitive costs. the numerous advantages of the manufactured composites with natural fibres is significantly contributing to the growth that is expected in textile production and will accelerate the predicted growth ratio for the next 10 years period near 5 %.   
  
 list of websites:   
  
 http://www.natex.eu/

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 from all the developed materials, an important effort has focussed in the modification and adaptation of suitable processing techniques for both thermoplastic and thermoset biocomposites production. thermoplastic biocomposites have been successfully processed by defined manufacturing techniques such as compression moulding, leading to good mechanical properties and surface finishing. considering thermosetting biocomposites, parts with good mechanical properties and surface appearance have been processed by rtm and methods. prepregs from furan resins and natural fibres have been processed by compression moulding leading to good mechanical properties and finishing.   
  
 potential impact:   
  
 with respect to the final applications of the project, different case studies have been selected to be developed from natural fabrics and both thermoplastic and thermosetting resins. requirements for these parts have been established and currently work is focussed on the development of first prototypes. good preliminary results have been obtained from the shipbuilding and transport system case studies showing a good prospect for the development of biocomposites from polymers reinforced with natural fibres.   
  
 the expected final results are that aligned natural fibres with improved properties will be combined with thermoplastics and thermosets, increasing the mechanical properties of biocomposites and introducing them in structural applications in different sectors such as transport, energy, agricultural machinery and shipbuilding.   
  
 considering the importance of the final application sectors, the versatility of use of the fabrics in conventional processes, and the nowadays limitations on the use of natural fibres in composites, an important replacement of the currently used traditional textiles and non-textiles by natural textiles is expected in the composites sector since these natural reinforcements are kept at competitive costs. the numerous advantages of the manufactured composites with natural fibres is significantly contributing to the growth that is expected in textile production and will accelerate the predicted growth ratio for the next 10 years period near 5 %.   
  
 list of websites:   
  
 http://www.natex.eu/

# DEPHOTEX

Project Acronym: DEPHOTEX

programme & topic: FP7-NMP NMP-2007-4.0-2

Most frequent returning words in objectives:

* ('project', 5)
* ('photovoltaic', 5)
* ('materials', 5)
* ('market', 5)
* ('textiles', 4)
* ('years', 4)
* ('energy', 4)
* ('textile', 4)
* ('dephotex', 3)
* ('research', 3)
* ('applications', 3)
* ('devices', 3)
* ('spain', 3)
* ('germany', 3)
* ('s.a.', 3)
* ('cells', 3)
* ('properties', 3)
* ('fabric', 3)
* ('specifications', 3)
* ('markets', 3)
* ('substrate', 3)
* ('development', 2)
* ('power', 2)
* ('november', 2)

dephotex is a european collaborative research project aiming at the development of flexible photovoltaic textiles to power wearable consumer goods, grid connected systems, as well as off-grid applications. the project of 4.2 million is co-funded by the european commission (fp7-nmp) for 3 years. dephotex started last 1 november 2008 and is coordinated by cetemmsa, a spanish technological centre specialised in smart devices and smart materials. the consortium is composed of a multidisciplinary team of highly experienced european entities from several countries:  
  
fundacio privada cetemmsa (spain)  
wetenschappelijk en technisch centrum van de belgische textielindustrie (centexbel, belgium)  
grado zero espace srl (italy)  
deutsches textilforschungszentrum nord-west (germany)  
asociacion de la industria navarra (spain)  
centro ricerche fiat s.c.p.a. (italy)  
brno university of technology (czech republic)  
centro de nanotecnologia e materiais tecnicos, funcionais e inteligentes (portugal)  
national renewable energy centre (spain)  
bavarian center for applied energy research (germany)  
nanocyl s.a. (belgium)  
texteis penedo s.a. (portugal)  
julius-maximilians-universitat wurzburg (germany)  
greatcell solar s.a. - dyesol italia s.l. (switzerland/italy).  
  
photovoltaic (pv) is a promising market. indeed, the global market for energy harvesting devices is expected to rise strongly in the coming years, and the market share of photovoltaic is forecasted to reach more than 60 % of the global market in 10 years.  
  
with efficiencies growing up, state of the art pv cells offer a good solution to harvest solar energy. however they are still lacking of flexibility and conformability to integrate them in common objects or cloths.  
  
moreover, many sun-exposed surface areas are textile-based, like garments, car interiors, home or outdoor textiles. dephotex will therefore fill the gap by developing photovoltaic textiles with properties inherent to fabrics: flexibility, weight, durability, water/dust resistance, which are properties that will only be feasible if the fabric itself turns to be photovoltaic.  
  
the project started on november 2008 by the analysis of the specifications required for different market sectors: wearable applications, home and architecture textiles, automotive sector, other sectors like sport and leisure. these specifications include geometrical dimensions, durability, electrical properties (voltage, power,...), cost sustainability, etc. these data will drive the project outputs all along the three years to ensure adequacy of the prototypes with the identified markets.  
  
the second technical step deals with the development of conductive textile as substrate for the pv cells. among the materials considered, carbon nanotubes and conductive polymers are extensively studied to evaluate their potential as a substrate to build the pv cells. other organic and inorganic materials are also subject to tests and fabric prototyping. adequacy with final product specifications and industrial tools is the main driver.  
in parallel to this activity, research on pv active materials, barrier materials and deposition techniques is carried out to pave the route for the launch of the two main work packages dedicated to the fabrication of the devices.  
  
indeed, two techniques will be employed to prepare prototypes for different markets:  
  
- building from the bottom layer (textile substrate);  
- building from the top layer (barrier film and top electrode).  
  
while the first one will aim at applications where pieces of fabric can be processed in industrial tools, the other one allows to produce 'pv patches' that can be pasted on large surface area textile (ex: large stadium awnings) that cannot be processed in the factory. this technology breakdown not only duplicates the project success chances, but also allows addressing different markets and manufacturing industries (textile and printed electronic manufacturers).  
  
http://www.dephotex.com

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# PROCON

Project Acronym: PROCON

programme & topic: FP7-IDEAS-ERC ERC-SG-SH6

Most frequent returning words in objectives:

* ('textiles', 9)
* ('italy', 8)
* ('textile', 8)
* ('production', 7)
* ('project', 5)
* ('consumption', 5)
* ('greece', 4)
* ('regions', 4)
* ('yarn', 4)
* ('europe', 3)
* ('exchange', 3)
* ('economy', 3)
* ('iron', 3)
* ('differences', 3)
* ('fibre', 3)
* ('draft', 3)
* ('fibres', 3)
* ('flax', 3)
* ('technology', 3)
* ('procon', 2)
* ('urbanisation', 2)
* ('mediterranean', 2)
* ('development', 2)
* ('implications', 2)

the procon project investigates the significance of the production and consumption of textiles during the period of urbanisation in mediterranean europe (1000-500 bce). the focus is on the role of the production and consumption of textiles for the development of city-states (as clothing, elite regalia, trade and exchange items) and the implications of this for other aspects of the economy, such as the use of land, labour resources and the development of urban lifestyle. in terms of scale, the project is concerned with broad patterns and adopts a mediterranean-wide rather than a regional perspective, examining evidence from italy, greece and spain. the economy of textile production is furthermore conceived as a network that stimulated the mobility of goods, people, ideas and technologies in the context of developing urbanisation. the procon structure thus encompasses four research strands within the operational sequence of textile economy: resources; production; product; and consumption and exchange. the project is highly interdisciplinary and draws on methods from the fields of archaeology, biology, geology, chemistry, art history and classics, examining archaeological textiles, textile tools, palaeoenvironmental remains, iconographic and written sources.  
  
the first half of the project duration was dedicated to data collection in museums of italy, germany, austria, greece and the uk, recording textiles, tools and iconography. our preliminary analyses suggest that, during the iron age, and possibly already much earlier, most of italy shared the twill textile culture of central europe (specifically eastern hallstatt), while greece followed the near eastern tradition of weft-faced tabby and tapestry. weft-faced tabbies are also documented in italy, but are restricted to eastern adriatic regions and southern italy where they appear in the contexts dating after the foundation of greek colonies, or are found in exceptional etruscan and lacial burials, which also contain unusual quantities of eastern imports. based on its geographical and chronological occurrence, it is likely that this type of textile may be connected with hellenic influence in italy. functional tool analysis indicates similar differences in the types of textiles produced in the regions under consideration. iconographic analysis also appears to support the differences seen in textiles, indicating that, whilst taking the biases inherent in this type of evidence into account, it may be used as a reliable source to ascertain broader patterns of textile consumption. this difference between the textile cultures of italy and greece has never been noted before and has important implications for our understanding of textile production and consumption preferences in these two regions, including differences in raw materials, techniques, organisation of production and exchange with neighbouring regions.  
  
another significant discovery of the project is the identification of the textiles (as well as threads) woven with plied linen yarn that has been spliced rather than draft-spun. splicing is a technique used to convert plant fibre into yarn that, until recently, has been assumed to be used exclusively in ancient egypt and the far east. in contrast to draft spinning, during which the combed and prepared fibres are fixed on a distaff and are continuously drawn to receive a twist imparted during the rotation of a spindle, in splicing, the ends of pre-formed flax fibre bundles stripped from flax stalks are spliced, so that the ends of the fibres would overlap in bunches. splicing has recently been identified in neolithic textiles found in the alpine lake region, and our study demonstrates that, in italy and possibly more widely in europe, plant fibres were transformed into yarn by splicing rather than draft spinning well into the iron age. this means that flax fibre continued to be spliced throughout the bronze and iron age even as draft spinning technology using spindle developed with the increasing popularity of wool. the change occurred around the 6th c. bce, likely because of the need for larger quantities of linen yarn and cloth, and potentially a faster thread production technology required for sails and other utilitarian textiles. the shift in technology was likely a consequence of increasing and changing demands of the mediterranean urban societies.

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# Force7

Project Acronym: Force7

programme & topic: FP7-SME SME-2012-1

Most frequent returning words in objectives:

* ('conditions', 21)
* ('recovery', 21)
* ('water', 17)
* ('project', 15)
* ('spill', 14)
* ('structure', 14)
* ('textile', 13)
* ('equipment', 13)
* ('result', 13)
* ('skimmer', 13)
* ('force', 12)
* ('developed', 12)
* ('system', 11)
* ('mops', 10)
* ('behaviour', 9)
* ('onboard', 9)
* ('efficiency', 9)
* ('fibres', 8)
* ('performances', 8)
* ('structures', 8)
* ('scale', 8)
* ('design', 8)
* ('results', 8)
* ('collection', 7)

executive summary:  
accidental oil spills still occur in european and worldwide waters, causing huge disasters such as haven and exxon valdez wreckages, or deepwater horizon spill in the gulf sea in 2010. in the last few years three of the largest spills in the world ever have occurred in western europe, letting alone the number of deliberate illegal âoperationalâ discharges of oily waste from vessels happening daily which are responsible for the chronic oil pollution of our marine environment.  
the sea around us is by no means as heavily polluted as it was in the first half of the 20th century, while response activities to contain and recover spilled oil have not changed dramatically over the past 25 years.  
in line with current trends in offshore drilling, which are increasingly moving operations towards the arctic seas, force7 aims to develop advanced new technologies for oil spill responding in extreme conditions, providing a sustainable and high-performing solution for oil pollution recovery in case of icy water and high swelling.  
force7 approach is based on the development of advanced textile architectures in shapes of mops, exploiting the latest knowledge available from materials research and the full potential of cfd numerical modelling to provide cheaper, easier to deploy and more efficient oil slick recovery solutions.  
the new mops can be deployed astern from a tugboat and dragged to absorb the oil slick, or lifted and released vertically on confined spots. the mops are made by novel fibres with controlled oleo-phylic and water-phobic behaviour in order to absorb large quantities of oil and not water, put together with a special multilayer textile structure conceived to maximize collection of heavy oil in cold weather. once the mops are saturated they are recovered onboard of the vessel and squeezed through a roller system. the oil collected is recovered and the mops are deployed again for another cycle.   
compared to standard solutions, which are largely inefficient when sea conditions become severe, force7 material solutions promise competitive advantages: having the possibility to increase the absorption characteristics, improving responding effectiveness and saving costs of equipment.  
the system has been tested in a confined tank to measure oil sorption performances, overcoming 92% oil recovery efficiency well above the initial objectives. the full-scale system has been verified with repeated dragging/retraction cycles confirming up to 66% decreasing of operational costs.  
project context and objectives:  
different technologies are already available for the removal of oil spilled in water after an accident, each with pros and cons and with applicability depending on the specific operation conditions (e.g. oil type, water conditions, etc.). currently, there is no technology that can successfully recover spilled oil in dynamic ice typical of the arctic and heavy seas, conditions often found in the extreme northern and southern regions of the globe where the exploitation of new oil fields is constantly increasing.   
force 7 aims at developing an innovative oil spill recovery system for operation in rough sea conditions. the new system is based on the use of a system of interconnected mops to be deployed astern from a tugboat and dragged to absorb the oil slick. the mops are made by novel fibres with controlled oleo-phylic and water-phobic behaviour in order to absorb large quantities of oil and not water, put together with a special multilayer textile structure conceived to maximize collection of heavy oil in cold weather. once the mops are saturated they are recovered onboard of the vessel, squeezed through a roller system; the oil collected is recovered and the mops are deployed again for another cycle. traditional systems, in comparison, are characterised by lower performance in terms of oil recovery efficiency and cannot be used in harsh sea conditions, which are typically encountered in northern seas.  
s/t objectives characterizing the project are:  
fibrous materials:  
â¢ to characterize the behaviour and performances of technical (pp based) and recycled natural fibres in terms of oleophilicity and hydrophobicity and resistance to harsh conditions (cold temperature, saltwater), including special surface treatments and different types of structures (nonwoven, net-like structures, rope-like structures, 3d structures); to develop effective production methodologies for pp-based modified fiber, including production of sub-micron fibers based on bicomponent technology and po foam/fiber materials for oil recovery systems;   
textile structures:  
â¢ to develop advanced textile structures allowing optimized wettability, buoyancy and mechanical performance when operated ni water, allowing for increased efficiency in oil recovery and targeting increased reusability compared to conventional skimmers; to study production process scalability and sustainability up to industrial scale production in order to be able to produce the required quantities of materials requested to satisfy the demand generated by large oil spills;  
oil recovery equipment:  
â¢ to extend the state of the art and knowledge about behavior of oil recovery systems under extreme water conditions; to design and assembly of components in large scale oil recovery systems characterized, compared with conventional systems, by higher reusability, higher strength, higher absorbance, fastest working, higher economical sustainability and higher environmental friendliness; to achieve a significant increment of recovery efficiency and oil recovery rate for the full-scale equipment, thanks to the use of advance textile concepts, with target re higher than 90% for al concepts and orr which strongly depend from oil type and water conditions; to perform a field demonstration of full-scale oil recovery system for large water areas taking into account durability, regeneration, cost efficiency, easy deployment, extreme conditions; to achieve a cost saving of about 66% of operational and capital costs using the new mop system for oil recovery in heavy seas compared to recovery using containment booms.  
  
project results:  
textile mop structure:   
the mop design has been developed in order to optimize use in cold seas where oils spilled behave as heavy oil grades: in particular, priority has been given to âmechanicalâ collection (high void net-like structure, which exploits high stickiness of heavy oil grades) instead of capillarity absorption (which becomes predominant with light oil grades).  
each mop tail is composed of a four-layer 3d textile structure with specific design oriented to maximize the collection and release of heavy oils, thanks to a âmultiple wingâ configuration. outer layers are made of a net-like crochet knitted structure, made of pe multifilament tape similar to synthetic grass grades tied with standard pp monofilament. this layer gives the required stiffness to the structure, avoiding folding while providing sufficient mobility and void grade. inner layers are made of a net-like crochet knitted structure, where a special pp braid is tied with standard pp monofilament (red). the special pp grade filament section has been developed to provide high affinity with oil grades and high void grade, so that both heavy and light oils can be collected. the 4 layers stitched together with a high-strength tensioning belt providing sufficient mechanical resistance to be dragged on the water.  
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â¢ iosc 2014 (internation oil spill conference), savannah (georgia, usa) , 5-8 may 2014  
â¢ euratex tfe meetings , brussels (be), 19 june 2014 and 24 november 2014  
â¢ smau milano, milan (ita), 22-24 october 2014  
â¢ nanoitaltex 2014, biella (ita), 12 november 2014  
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â¢ result 3: nonwoven structures and mop construction for oil absorption + design of high-performance tensioning media for mop skimmer integration and operability   
â¢ result 4: force7 onboard equipment for oil spill responding  
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san donato milanese (milan)  
italy

# Force7

Project Acronym: Force7

programme & topic: FP7-SME SME-2012-1

Most frequent returning words in objectives:

* ('conditions', 21)
* ('recovery', 21)
* ('water', 17)
* ('project', 15)
* ('spill', 14)
* ('structure', 14)
* ('textile', 13)
* ('equipment', 13)
* ('result', 13)
* ('skimmer', 13)
* ('force', 12)
* ('developed', 12)
* ('system', 11)
* ('mops', 10)
* ('behaviour', 9)
* ('onboard', 9)
* ('efficiency', 9)
* ('fibres', 8)
* ('performances', 8)
* ('structures', 8)
* ('scale', 8)
* ('design', 8)
* ('results', 8)
* ('collection', 7)

executive summary:  
accidental oil spills still occur in european and worldwide waters, causing huge disasters such as haven and exxon valdez wreckages, or deepwater horizon spill in the gulf sea in 2010. in the last few years three of the largest spills in the world ever have occurred in western europe, letting alone the number of deliberate illegal âoperationalâ discharges of oily waste from vessels happening daily which are responsible for the chronic oil pollution of our marine environment.  
the sea around us is by no means as heavily polluted as it was in the first half of the 20th century, while response activities to contain and recover spilled oil have not changed dramatically over the past 25 years.  
in line with current trends in offshore drilling, which are increasingly moving operations towards the arctic seas, force7 aims to develop advanced new technologies for oil spill responding in extreme conditions, providing a sustainable and high-performing solution for oil pollution recovery in case of icy water and high swelling.  
force7 approach is based on the development of advanced textile architectures in shapes of mops, exploiting the latest knowledge available from materials research and the full potential of cfd numerical modelling to provide cheaper, easier to deploy and more efficient oil slick recovery solutions.  
the new mops can be deployed astern from a tugboat and dragged to absorb the oil slick, or lifted and released vertically on confined spots. the mops are made by novel fibres with controlled oleo-phylic and water-phobic behaviour in order to absorb large quantities of oil and not water, put together with a special multilayer textile structure conceived to maximize collection of heavy oil in cold weather. once the mops are saturated they are recovered onboard of the vessel and squeezed through a roller system. the oil collected is recovered and the mops are deployed again for another cycle.   
compared to standard solutions, which are largely inefficient when sea conditions become severe, force7 material solutions promise competitive advantages: having the possibility to increase the absorption characteristics, improving responding effectiveness and saving costs of equipment.  
the system has been tested in a confined tank to measure oil sorption performances, overcoming 92% oil recovery efficiency well above the initial objectives. the full-scale system has been verified with repeated dragging/retraction cycles confirming up to 66% decreasing of operational costs.  
project context and objectives:  
different technologies are already available for the removal of oil spilled in water after an accident, each with pros and cons and with applicability depending on the specific operation conditions (e.g. oil type, water conditions, etc.). currently, there is no technology that can successfully recover spilled oil in dynamic ice typical of the arctic and heavy seas, conditions often found in the extreme northern and southern regions of the globe where the exploitation of new oil fields is constantly increasing.   
force 7 aims at developing an innovative oil spill recovery system for operation in rough sea conditions. the new system is based on the use of a system of interconnected mops to be deployed astern from a tugboat and dragged to absorb the oil slick. the mops are made by novel fibres with controlled oleo-phylic and water-phobic behaviour in order to absorb large quantities of oil and not water, put together with a special multilayer textile structure conceived to maximize collection of heavy oil in cold weather. once the mops are saturated they are recovered onboard of the vessel, squeezed through a roller system; the oil collected is recovered and the mops are deployed again for another cycle. traditional systems, in comparison, are characterised by lower performance in terms of oil recovery efficiency and cannot be used in harsh sea conditions, which are typically encountered in northern seas.  
s/t objectives characterizing the project are:  
fibrous materials:  
â¢ to characterize the behaviour and performances of technical (pp based) and recycled natural fibres in terms of oleophilicity and hydrophobicity and resistance to harsh conditions (cold temperature, saltwater), including special surface treatments and different types of structures (nonwoven, net-like structures, rope-like structures, 3d structures); to develop effective production methodologies for pp-based modified fiber, including production of sub-micron fibers based on bicomponent technology and po foam/fiber materials for oil recovery systems;   
textile structures:  
â¢ to develop advanced textile structures allowing optimized wettability, buoyancy and mechanical performance when operated ni water, allowing for increased efficiency in oil recovery and targeting increased reusability compared to conventional skimmers; to study production process scalability and sustainability up to industrial scale production in order to be able to produce the required quantities of materials requested to satisfy the demand generated by large oil spills;  
oil recovery equipment:  
â¢ to extend the state of the art and knowledge about behavior of oil recovery systems under extreme water conditions; to design and assembly of components in large scale oil recovery systems characterized, compared with conventional systems, by higher reusability, higher strength, higher absorbance, fastest working, higher economical sustainability and higher environmental friendliness; to achieve a significant increment of recovery efficiency and oil recovery rate for the full-scale equipment, thanks to the use of advance textile concepts, with target re higher than 90% for al concepts and orr which strongly depend from oil type and water conditions; to perform a field demonstration of full-scale oil recovery system for large water areas taking into account durability, regeneration, cost efficiency, easy deployment, extreme conditions; to achieve a cost saving of about 66% of operational and capital costs using the new mop system for oil recovery in heavy seas compared to recovery using containment booms.  
  
project results:  
textile mop structure:   
the mop design has been developed in order to optimize use in cold seas where oils spilled behave as heavy oil grades: in particular, priority has been given to âmechanicalâ collection (high void net-like structure, which exploits high stickiness of heavy oil grades) instead of capillarity absorption (which becomes predominant with light oil grades).  
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italy

# NATEX

Project Acronym: NATEX

programme & topic: FP7-NMP NMP-2007-4.0-2

Most frequent returning words in objectives:

* ('fibres', 7)
* ('composites', 5)
* ('textiles', 4)
* ('project', 4)
* ('properties', 4)
* ('natex', 3)
* ('fibre', 3)
* ('yarns', 3)
* ('website', 3)
* ('fabrics', 2)
* ('produce', 2)
* ('thermoplastics', 2)
* ('thermosets', 2)
* ('process', 2)
* ('textile', 2)
* ('developed', 2)
* ('resin', 2)
* ('vacuum', 2)
* ('compression', 2)
* ('sectors', 2)
* ('growth', 2)
* ('development', 1)
* ('strength', 1)
* ('parts', 1)

natex is focused on the development of aligned textiles from natural fibres suitable for use as high strength reinforcing fabrics to produce structural composite parts using bio and oil based thermoplastic and thermoset resins. this includes the use of orientated woven natural fibres in bio-derived thermoplastics and thermosets, to produce high-tech products with high added value from entirely renewable resources.  
  
the main innovations in natex project are:   
 - modification of the fibre surface to obtain the desired interface properties when combined with the polymer matrix.   
 - new spinning process to reduce the yarns' twisting during the textile manufacturing process, increasing the fibre volume fraction and the wetting of the fibres. this is going to increase the mechanical properties of the yarns.   
 - new weaving techniques are being developed to improve impregnation and to obtain innovative 3d textiles.  
 - new commingling and film stacking is being developed for thermoplastic composites, for improving the permeability of the composite and to obtain well mingled yarns.  
  
besides, a large range of resin processing methods will be adapted to suit them to the characteristics of the modified fibres: vacuum bagging, vacuum consolidation, compression moulding, continuous compression moulding, infusion and resin transfer moulding. basic research on joining technologies as hot welding over natural fibre composites will be also performed.   
  
as a result, aligned natural fibres with improved properties will be combined with thermoplastics and thermosets, increasing the mechanical properties of biocomposites and introducing them in structural applications in different sectors: transport, energy, agricultural machinery and shipbuilding.  
  
considering the importance of the final application sectors, the versatility of use of the fabrics in conventional processes, and the nowadays limitations on the use of natural fibres in composites, an important replacement of the currently used traditional textiles and non-textiles by natural textiles is expected in the composites sector since these natural reinforcements are kept at competitive costs. the numerous advantages of the manufactured composites with natural fibres is significantly contributing to the growth that is expected in textile production and will accelerate the predicted growth ratio for the next 10 years period near 5 %.  
  
the natex website, http://www.natex.eu/, was established at the beginning of the project. deliverable 9.5 'project website' gives an overview of the main functionalities and structure of the website. the main structural difference is based on the intended audience: the public at large (industry stakeholders, academia, eu and national officials, etc) and/or the beneficiaries involved in the project, the consortium.

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# MAPICC 3D

Project Acronym: MAPICC 3D

programme & topic: FP7-NMP NMP-2010-3.4-1

Most frequent returning words in objectives:

* ('mapicc', 72)
* ('composites', 31)
* ('production', 28)
* ('part', 27)
* ('structures', 24)
* ('development', 23)
* ('project', 20)
* ('design', 20)
* ('risks', 20)
* ('truck', 20)
* ('properties', 19)
* ('manufacturing', 18)
* ('technology', 18)
* ('lightweight', 17)
* ('energy', 16)
* ('cost', 15)
* ('preforms', 15)
* ('materials', 15)
* ('process', 14)
* ('structure', 14)
* ('textile', 13)
* ('auto', 13)
* ('ensait', 13)
* ('rail', 13)

executive summary:  
the objective of mapicc 3d project is the development of novel industrial automated and cost efficient integrated processes able to produce high performance multifunctional light weight structural thermoplastic composites at high quality. the processes are based on new technologies for the in line production of upgraded 3d textile preforms and composites from thermoplastic hybrid yarns comprising various fibres (glass, polymeric reinforcing fibres). the composites are dedicated to application areas such as industrial transport (automotive, railway and aeronautic), building and energy applications.  
the main advantage of these new technologies are the direct production of 3d preforms with controlled 3-directional fibre placement in a fully interlaced manner, the capacity to predict properties of the final composites, and the possibility to integrate quality sensors, tubes or wires. furthermore, it will be possible to produce curved panels and beams with complex cross sections at a high quality level and with high design flexibility at low manufacturing costs, low manual operations and ensuring a high reliability.  
more precisely the innovative concept of mapicc 3d is based on the:  
- development of thermoplastic hybrid yarns consisting of matrix and reinforcing component potentially also including a functional material component,   
- development of technological concepts able to precisely steer the fibres in 3d and tailor the mechanical properties of composites,  
- development of modelling tools able to predict the final properties of designed 3d preforms and final composites and allow easier design of customised end products and better synchronisation sme/oem,  
- development and demonstration of equipment able to produce 3d preforms of stiffeners and panels directly,  
- development and demonstration of highly efficient automated and highly adaptable manufacturing system for high volume production of textile preforms and out of that thermoplastic composites at industrial scale (using high pressure and temperature)   
- demonstration of real applications possibilities for of lightweight composites as replacement for metal structures in automotive, railway and energy industry.   
mapicc 3d process is expected to ensure:  
- a highly reliable production rate of between 5 and 20 m2/h, at acceptable cost; depending on the complexity of the preform structure  
- a productivity improvement of 30% compared to current 2d preform methodologies  
- an optimisation of logistics and improvement of logistics of time to market by 15%.  
- a composite with highly improved and reliable mechanical properties, which are able to replace selected metallic structures in transport, energy and building industry and  
- a substantial reduction of waste with a rational use of raw materials.  
the major innovation of mapicc 3d is to manufacture the preforms directly, avoiding all joining steps to enable a weight reduction of structures. even if the cost of the technology investment may be higher, the final price of the composites will be lower than existing manufactured composites with current technologies due to the absence of expensive manual joining steps. moreover, delamination risks of complex forms can be reduced while improving performance and cost effectiveness. the important potential markets around lightweight complex structures quantize a rapid redemption of investment. the project comprises 20 partners from 10 countries including 7 large industries, 6 smeâs, 6 universities and 1 association. it integrates the whole manufacturing chain from raw materials selection to design; including hybrid yarn developers, 3d preforms technology developers, modelling/simulation tools specialists, automatic systems, industrial equipment suppliers and industrial end users of lightweight materials.  
  
project context and objectives:  
a) the current context in complex lightweight composite structure production   
one of the priorities in transport but also others industries (building and energy) is to develop lightweight complex structures with high mechanic and quality performances, in order replace the metallic heavy pieces. in fact, the demand of energy efficient environment friendly vehicles for transport industries is increasing. such vehicles are expected to be lightweight for less energy consumption as well as for minimum co2 emission, high performance, reliability, recyclability, cost effective production, safety and comfort. an important issue is to reduce the material types, to enhance recycling, but without scarifying the notion of performance at affordable cost. the needs concerning composites structure is increasing; however there is still major breakthrough limit acting against their development, which are the following:   
o high cost production   
o long and labor-intensive production,   
o quality issues  
o lack of versatile and flexible process  
o tailored properties difficult to achieve with current technologies   
o low qualified skillness.   
moreover the lack of modeling tools to virtually prototype products, to evaluate the manufacturability and performances properties, prevents the synchronization of smes and oems for manufacturing of high volumes of customized lightweight complex composite products.   
b) limits of 2d preform production   
the composite industry uses currently 2d preforms, as reinforced textiles structures. 2d preforms are usually manufactured using woven, braided and unidirectional structures implying high strength, stiffness and damage tolerance in impact loading. knitted fabric composites, for instance, have the highest deformability and impact resistance among the textile based composites. due to the unidirectional structure of 2d preform, in order to achieve requested mechanical properties of final composites, the production steps are composed by long and complex operations: cutting, performing, impregnation, curing, trimming and joining (fig 1).   
 c) 3d preforms production: a new challenge for low cost and tailored complex lightweight composite structures  
in order to achieve the lightweight composite structures composites particularly for transport applications, the following barriers should be overcame:   
o development of new textiles technologies able to produce at high speed 3d fibrous structures with tailored yarn paths to improve mechanical properties of composites parts.   
o development of virtual tools able to model the 3d structure and to predict the mechanical behavior of final composites, according to textile architecture and the resin choice  
o improvement of the level of security and quality during the whole life of composites structures, by dynamically controlling the state of the structure  
o high volume composite production rate with a minimum of raw material rejection   
the major challenge for industrial scale 3d shaped structure manufacturing consists in developing integrated textile structures and automated technologies able to manufacture directly in three dimensions (x, y, z) the preforms of composite which constitutes the skeleton of composite structures.   
d) the concept proposed by mapicc3d project  
the new concept of mapicc3d for 3d high volume production of composite lightweight are based on:   
o the development of a new technology, steering the placement of fibres in 3 directions x, y and z, able to produce complex 3d performs : stiffeners and panels (fig 1.2) these two types of part are generic and cover the major need of structural components requested by transport industries but also for other industries (energy, building).   
o the adaptation of up-graded thermoplastic hybrid yarns, which can act both as matrix and reinforcing phase, and which can also host a functional material component. this material will be specifically adapted to the new technologies and avoid the polluting step of impregnation by a liquid resin   
o the development of modeling tools to design, characterize and predict the behavior of 3d preforms  
o the automatic process manufacturing of selected complex lightweight composite structures  
inconvenient of 2d performs advantages of 3 d performs developed in mapicc 3d  
â¢ steer the position of yarns in two directions x,y  
â¢ damage on tensile stiffness, strength and failure mechanisms of fibre yarns ( a 30% loss of strength of load-bearing dry yarns respectively 50% in the z-binder)  
â¢ problems of delamination  
â¢ preforming is a costly and complex task   
â¢ steer the position of yarns in three directions x,y and z : improved mechanical properties  
â¢ avoid the steps of cutting, forming, joining during the realisation of the composites process : less of wastes and scraps (expected rate : 80 % of total volume of waste with current process)   
â¢ obtain directly in one shot the 3d preform : no discontinue process  
â¢ possibility to design complex shape directly  
â¢ possibility to obtain improved mechanical 3 d performs with cheaper fibres  
â¢ avoid the mechanical damages of yarns during the textile process  
â¢ master the quality of production, master the variability of properties of composites, reduce defects in products  
4.1.2.2 - objectives  
objectives of mapicc 3d  
the objective of mapicc 3d project is to develop novel industrial automated and cost efficient integrated processes able to product high performance and quality multifunctional light weight structural thermoplastic composites. the new processes are based on a new technologies of upgraded 3d textile preforms (fig 1.3) produced on line with thermoplastic hybrid yarns from various fibres (glass, polymeric, carbon reinforcing fibres) dedicated to industrial transport (automotive, railway and aeronautic) but also building and energy applications.  
the main advantage of this technology is the direct production of 3d performs with controlled 3-directional fibre placement in a fully interlaced manner, the capacity to predict the properties of the final composites, and the possibility to integrate quality sensors, tubes or wires and the capacity to produce curved panels and beams with complex cross sections of high quality, high design flexibility, low manufacturing costs, high reliability and low manual operations.  
   
more precisely the innovative concept of mapicc 3d (fig 1.4) is based on:  
- development of thermoplastic hybrid yarns which can act both as matrix and reinforcing phase including a functional material component,  
o the part of glass fibres will play the role skeleton of preforms, and allow to reinforce the composite structure. the thermoplastic part will play the role of polymer matrix. the proprietary thermoplastic/glass fiber technology is designed to produce reinforcements with superior mechanical properties, particularly in regard to stiffness-to-weight ratio and impact resistance. use of thermoplastic materials, possible in special forms as bicomponent yarns, in composite materials to obtain the same mechanical and structural specifications as the more conventional used materials. a significant environmental advantage of utilizing thermoplastic composites and vacuum bag closed molding technology is that no emissions are produced during the curing process.  
- development of a technological concept able to precisely steer the fibres in 3d and tailor the mechanical properties of composites,  
- development of modelling tools able to predict the final properties of designed 3d performs and final composites and allow easier design of customised end products and better synchronisation sme/oem,  
the consortium will benefit of the following tools   
â¢ modeling tool in order to understand the mechanism of the new technologies and to represent the 3d preform  
â¢ predictive tool in order to virtually evaluate the mechanical performances of final 3d preform and final composite structures   
â¢ reverse engineering tools : industrial partners could according to the requirement of final composites structures and conditions of use, design by reverse engineering the 3d performs and find the optimal configuration. the cost and the speed of production factors will be included in the optimal design of the preform   
- development and demonstration of equipment able to produce directly 3d performs of stiffeners and panels,  
- development and demonstration of highly efficient automated and highly adaptable manufacturing system for high volume production in industrial scale of thermoplastic consolidation of textile performs (using high pressure and temperature) to produce on line the composite structures,  
- demonstration of real applications of lightweight composite manufacturing for metal structure replacement in automotive, railway and energy industry .  
mapicc 3d process is thus expected to ensure:  
- a highly reliable production rate comprised between 5 and 20 m2/h, at acceptable cost, accordingly to the complexity of preform structure  
- a productivity improvement of 30% comparing to current 2d preform methodologies  
- an optimisation of logistics and improvement of logistics of time to market of 15% .  
- a highly improvement and reliable mechanical properties able to replace metallic structures in transport, energy and building industry.  
- a substantial reduction of waste with a rational use of raw materials  
the major innovation of mapicc 3d is to realise the preforms directly, avoiding all joining steps to deal with the weight reduction of structures. even if the cost of technology investment could be higher, the final price of composite will be lower than existing manufactured composites with current technologies due to the absence of expensive manual joining steps. moreover delamination risks of complex forms can be reduced improving costs. the important potential markets around lightweight complex lightweight structures quantize a rapid redemption of investment.  
the project gathers 20 partners from 10 countries including 7 large industries, 6 smes , 6 universities and 1 association. the project integrates from the whole chain from raw materials selection and hybrid yarn development, to 3d performs technology developers, and modelling/simulation tools specialists and from automatic systems and industrial equipment suppliers to industrial end users of lightweight materials from transport and energy industry.  
figure 1.5 presents the implementation of mapicc 3d technologies in industrial fields and compare with the current composite production chains:   
  
project results:  
a) main exploitable results  
at the end of the project, the following key exploitable results (kers) have been identified:  
 exploitable result ipr owners of the er partners planning to exploit planned additional partners main risks to be addressed  
1 auto mapicc ensait, mecaplast, ttf, tencate ensait, mecaplast, ttf, tencate, tudd/ifkm, tudd/itm, polimi tbd  
car maker market risks  
technology risks  
financial risks  
  
2 truck mapicc ensait, rtu, ttf ensait, mecaplast, rtu, tencate, tudd ifkm, tudd itm, ttf tbd market risks  
technology risks  
financial risks  
3 aero mapicc ensait, rtu, ttf, tencate, reden ensait, rtu, polimi, ttf, tencate, reden tbd   
aircraft producers market risks  
technology risks  
financial risks  
partnership risks  
4 rail mapicc ensait, alstom, ttf ensait, alstom, ttf tbd market risks  
technology risks  
financial risks  
5 tools mapicc ensait, steiger, tudd/ifkm, tudd/itm ensait, steiger, tudd/ifkm, tudd/itm tbd  
industrial partner market risks  
technology risks  
financial risks  
  
apart from the kers listed above some other mapicc3d results are going to be exploited. those include the software developed by esi group, for composite manufacturing that will be exploited by this partner in further work.  
1 â auto mapicc  
oil pan is a good example regarding the price challenge to reach for automotive part. most of the oil pan for vehicle are in steel, so the production process is well optimize. car maker have tools and the technical knowledge to develop such part with the help of steel supplier. steel price as row material is cheaper that polyamide (grade of thermoplastic request because the oil pan need to support the temperature of hot oil). so basically if the compare only the oil pan in steel with a thermoplastic one the price of the steel is lower. but with a thermoplastic solution we can propose the integration of several function, that the car maker has to include during the mounting of the car. at the end we will be able to provide the full function, and the customer could save time in the mounting. by this way we can challenge the price of the steel oil pan with a thermoplastic composite solution.  
different design of oil pan are existing, from basic case to other more complicated which are linked with the gear box or and engine bracket. in this case oil pan is a structural part. and we need to introduce composite thermoplastic to give this structure.  
the substitution of steel for oil pan, will be possible thanks to the high mechanical properties of mapicc 3d output products. the new mapicc 3d composite structure will ensure:  
â¢ resistance to gearbox dynamical efforts;  
â¢ improvement of powertrain rigidity;  
â¢ resistance to stone impacts;  
â¢ perfect sealing from -30â°c to 160â°c  
different architectures have been investigated addressing a system made with the engine, gear box and oil pan. the aim was to study the opportunity of a possible business if a structural part could be finalised with the help of composite thermoplastic.  
we see that nowadays more than 70% of the engine architecture have a link between the oil pan and the gear box. itâs means that the oil pan should be able to support the strength coming from the gear box, which are definitely all the couple issued from the engine.  
   
esi made a full simulation with one example of oil pan on which mecaplast has worked 5 year ago (the target of this study was to countertype a steel oil pan by a thermoplastic).  
in the case of the plastic part necessary strength and structural stiff was obtained using a complex ribbed geometry. this reinforcement could either be the fabrics produced by dresden, or the fabric from ensaits. using this approach the intention is to replace the complex ribbed geometry with a uniform geometry (similar to the steel case), with fabric reinforcement now replacing the function of the ribs.  
esi input the data of the knitted fabric of tud in his simulation software.  
   
example of the simulation of the draping of the fabric  
so we have at the end produced some over molded part on a press injection machine:  
   
as a conclusion:  
with mapicc project mecaplast test the production of thermoplastic composite part on a press injection machine in industrial condition. we have investigated organ sheet made with commingled yarn, and we have seen the possibility to have simulation test during the development of the part.  
  
2 â truck mapicc  
fuel economy is a key driver for the introduction of lightweight materials in the trucks. hence, weight reduction is strategically important. for the same reasons of car industry, ie consumption of fuel, co2 level, efficiency for the transport of the goods.  
volvo decide to works on a seat base for its truck because this part is not too big, this is a good example to study the behaviour of composite part regarding light weight, cycle live analyse, crash test, possibility to be weld or glue on the base of the truck.  
the actual part is made of steel it has 4 insert to fix the seat on its base. this part is welded on the base during the industrial process.  
one of the first goal of the project was to design the part by simulation. rtu has done the simulation in order to define the optimal shape of the part. a prototype mold has been made in 2013, and a first trial done with a fabric made of twintex yarn (blend of glass/polypropylene, avaible on the market).  
during present research the advantages of employing topology optimisation in design of truck cabin seat plate made of thermoplastic gfrp composite has been investigated. one of the possible solutions to this issue is creating of 3d woven or knitted fabrics with initially added thicknesses at the most stressed areas.  
woven design has been specially develop by ensait, to find the best design pattern for truck seat plate.  
for a knitted development a new innovative knitting machine prototype in cooperation with the partner steiger s.a. has been developed and used in project. the machine is characterized by an enlarged space between the needle beds, an active yarn feeding system and an innovative new warp yarn guide rail.  
a demonstrator has been finalized, showing the light weight of this technology against steel:  
   
business case  
   
this business case demonstrate that we still far from volvo part price target which is roughly 10â¬ and 14â¬ if we include the weight saving valorisation.   
however this seat plate does not allowed us to integrate more function. the technology development within mapicc3d âopen roadâ/perspective on further study as: design one bigger part instead of âxâ parts and produce it in one shot saving time, energy as well as reducing the overall emissions to air and water as well as production waste.  
but volvo has also test this part under pull out test, with a chemical bonding and the mapicc project show the possibility to use composite for such part.  
the cost difference with steel shows the request to include composite should integrate additional functions. this means a new kind of development including the introduction of composite from the beginning of the development.  
  
3 â aero mapicc  
coexpair is a company involve in aeronautic industry, coexpair supplies production equipment and engineering solutions for manufacturing of composite parts at lower cost with improved quality. the target of the company is to improve performance: lower weight, lower cost, shorter manufacturing cycle; composites is an opportunity. nevertheless, the product shall be re-engineered starting from its functional requirement to be successful.  
the demonstrator selected by coexpair was a f shape which could be used for different part in aeronautic. technologies use by coexpair is woven carbon fibre with rtm process with epoxy resin.   
prototype have been made with woven product made by ensait   
   
rtu has performed test on the prototype to characterise the product:  
   
characterizations have been finalised by rtu, regarding the specification provided by coexpair.  
conclusion:  
coexpair get an excellent collaboration with ensait, reden, rtu and ttf during the mapicc project. mould concept upgraded to make the production easier and faster  
activities shown potential in time-saving and process optimization during preforming but some improvement is needed at weaving level (to upgrade the handling of preform without damaging it).  
  
4 â rail mapicc  
alstom is a leader in production of railways transport equipment and mapicc is a possibility to study the ability of composite thermoplastic to be use inside a car-body structure.  
nowadays alstom is using a tubular cross in steel to connect tube of the car-body.  
   
design modification of the part foreseen to adapt it to a textile solution.  
   
solutions were define to form the textile to the final shape   
   
thermoforming device have been finalized for the woven structure  
for the cross stiffener the consolidation has been made through a water soluble mandrel, and then a thermos-consolidation.  
5 â tools mapicc   
finieris is a company specialized in the production of plywood, a lot of this product are used for transportation for truck or train.  
so finieris has selected for mapicc project as demonstrator to produce and check high performance plywood with glass fibre and polypropylene composite sandwich panel.  
as back ground there was already some studies made:  
i-core and v-core all-plywood sandwich plates (2010-2012)  
   
 the following prototype was developed:  
using metal bar to give the corrugated shape to the fabric , and after the sandwich made with the plywood go to oven for a heating process.  
  
several validations test have been made on the prototype like flexural test, mechanical properties and impacts test, to ensure that the sandwich perform the requirement as deck.  
final test have been made on a platform develop by finieris to check this kind of product  
   
conclusion:   
mapicc project gave the opportunity to finieris to develop:   
â¢ new type of combined plywood gf/pp panel  
â¢ validated methodology for sandwich panel design panel design  
but now the challenge for finieris will be to finalise the manufacturing scale up to be able to push this new product on the market.  
plywood is extensively applied and well known building material with ability to make wood mechanical properties more uniform in planar direction. moreover the plywood strength and stiffness properties are comparable with glass fibre reinforced plastic`s which by any means are extensively utilised by the industry.   
in addition, plywood manufacturing is one of most efficient means of wood processing. regarding high stiffness and relatively low price it is popular sheet material for various engineering and packaging applications. however once plywood total thickness extents over 30 mm the self-weight of the panel becomes unattractive for industry. therefore it becomes apparent to utilize âsandwich effectâ in order to increase the cross section stiffness/ weight ratio. however in case of sandwich structures with different stiffener core types, a cross linking parameters must be introduced in order to optimise the core topology for specific commercial products.   
main emphasis in current research has been devoted to experimental validation of numerical fe model of sandwich panels with corrugated and rib stiffened core as well as optimization of cross-section topology for these boards.  
  
4.1.4.3 â dissemination activities and exploitation of results  
industrial dissemination actions with dedicated posters to mapicc applications, planning of exhibitions for the period starting from the 1st of september 2014 to the 31th of december 2015:  
â¢ scientific dissemination of 16 communications and 4 publications through mapicc partners from the m24 to m36 period (d8.8)  
â¢ updating information of mapicc website, leaflet and new dissemination folder in the astride extranet of mapicc members.  
â¢ two training sessions organized :  
â¢ april 9th, 2013 âensait, roubaix, france  
â¢ tuesday 9th of december 2014 â volvo, lyon, france  
â¢ updating of the mapicc leaflet achieved by ana marija granjaric from zaghreb university (available for download on the mapicc website)  
â¢ updating of website mapicc and implementation of a dissemination folder in the mapicc extranet astride allowing to deposit abstracts or papers for mapicc members.  
â¢ design and achievement of three mapicc posters for industrial dissemination highlighting the main results of each industrial partner and their benefits (auto mapicc, rail mapicc and truck mapicc).  
â¢ eu project technical session planned during the texcomp conference on textile composites in leuven (16 to 20 september 2013) for mappic 3d, 3d light trans and fiberchain, with a total of 6 oral presentations (2 slots per eu project) and posters, chaired and organized by franã§ois boussu.  
â¢ second mapicc session during the autex 2013, 13th autex world textile conference, dresden, germany, 23 of may 2013, chaired and organized by franã§ois boussu.  
â¢ list of events and exhibitions (table 1 d8.8) for the period m30 to m48 for industrial dissemination (6 main events in europe)  
â¢ main topics of organized training sessions (d8.1)  
o 9th of april 2013 : lecture on laminateâs law behaviour, introduction to warp interlock weaving technology  
o 9th of december 2014 : raw materials for reinforced composites, crash test for truck application and an overview of environmental impacts on lca.  
in summary:  
industrial dissemination performed with 15 actions using dedicated posters to mapicc applications  
scientific dissemination of 90 communications and publications  
events for industrial dissemination mapicc applications date  
automotive composite congress, koln. auto mapicc december 2-4th 2014  
mappic meeting with volvo truck staff auto-mapicc, truck-mapicc, rail-mapicc december 9th 2014  
gla/gpa, paris. auto mapicc, truck mapicc, rail mapicc december 19th 2014  
futex, marcq en baroeul, france auto mapicc, truck mapicc, rail mapicc january 21 -22th 2015  
jec, paris, france auto mapicc, truck mapicc, rail mapicc march 10-12th 2015  
techtextil2015, frankfort, germany auto mapicc, truck mapicc, rail mapicc may, 4-7th 2015  
uptex (technical meeting), roubaix, france auto mapicc, truck mapicc, rail mapicc july 2nd 2015  
gla/gpa, paris, france auto mapicc, truck mapicc october 15th 2015  
composites meeting, nantes, france auto mapicc, truck mapicc, rail mapicc november 4 -5th 2015  
itma, milan, italy auto mapicc, truck mapicc, rail mapicc november 12 -19th 2015  
gdr week, roubaix, france auto mapicc, truck mapicc, rail mapicc november 24-27th 2015  
4.1.4.4 â project web-site  
http://mapicc3d.ensait.fr/  
contact: vladan koncar: vladan.koncar@ensait.fr  
   
potential impact:  
mapicc3d project proposes design solutions by textile composite materials to principally replace metallic structures in different applications (figure 1), such as a cross stiffener for rail application, a seat plate for truck application and a battery rack for automotive application. along with the economic aspects and business plans associated with the new concepts and involved manufacturing conditions, impacts of the new parts and their production cycle on the environment are to be considered. the objective of this deliverable is to list the different impacts that could be considered and to select them directly of interest to produce a relevant life cycle analysis (lca) at the current stage of part development.  
manufacturing industries generally have a negative impact on the environment in terms of use of earth extracted raw materials, use of toxic materials, waste and water consumption, gas emission and energy consumption.  
the use of composite to develop lightweight structures allows reduction of energy consumption during part use-phase (figure 1). a positive overall impact on the environment is thus expected. however, the manufacturing stage generally has a negative impact on the energy balance. the outcome would influence: human health, local natural environment, social and cultural aspects, global environment, resource sustainability. the following categories need thus to be assessed in order to complete a relevant analysis of the impact of the developed structures on the environment: use of petroleum resources, effect on health, carbon energy level, recyclability  
each category can compile a large amount of information associated with the environmental consequences of a technology. the following description of each impact category is here to help defining which outcomes can be expected from the technological choices drawn in mapicc3d.  
a description of each of the outcome categories is provided here in the context of mapicc3d demonstrators. the general route is summarized in figure 2 impacts on human health and/or safety. this category focuses on the potential impacts of a technology on the health, safety and well-being of workers. it can be associated closely with the general conditions and ergonomics at work. generally the following aspects are considered:  
â¢ communicable diseases resulting from sanitary hygiene, risk associated with handling of infectious wastes, and known contagious diseases  
â¢ injury or risk of accidents ranking from traffic, explosions, falls, heat stress, operation of machinery, handling of physically hazardous wastes and resources, loss of hearing  
â¢ exposure to hazardous chemicals from inhalation, skin contact, ingestion of contaminated goods of hazardous chemicals and of radioactive material.  
for the first point, communicable disease, as the materials considered in mapicc3d are found in europe, no direct risk is identified. for the second point however, linked with the risk of injuries, a study should be considered. the manufacturing of the seat plates, the battery rack cover and the cross stiffeners involve the use of: automated knitting or braiding machine, consolidation press, automated handling of preform and over molding injection machine.  
however the highly automated, different units presented here require qualified technicians. the individual protections are well-known in those cases, as well as security sensors associated with each production unit. risks when switching from a metallic part to composite part so long as human safety is considered are not increased, as stamping or moulding of metallic parts involves hi ...

# ECOLASTANE

Project Acronym: ECOLASTANE

programme & topic: FP7-SME SME-2012-2

Most frequent returning words in objectives:

* ('fibres', 36)
* ('ecolastane', 32)
* ('production', 30)
* ('biomass', 23)
* ('synthesis', 23)
* ('elastane', 20)
* ('process', 15)
* ('textile', 14)
* ('technology', 14)
* ('polyester', 13)
* ('chemical', 12)
* ('industry', 11)
* ('lignocellulose', 11)
* ('novel', 11)
* ('method', 11)
* ('chemicals', 10)
* ('performance', 9)
* ('purification', 9)
* ('costs', 9)
* ('solution', 8)
* ('monomers', 8)
* ('materials', 8)
* ('products', 8)
* ('textiles', 8)

executive summary:  
ecolastane has been designed to overcome the technical obstacles preventing our value chain from addressing the common needs of bio-based chemicals and bio-based synthetic fibres as a technical solution providing the whole community with strengthened competitive advantage.  
around 25% of the fibres consumed in europe are natural (cotton, wool, silk), while man-made fibres represent 75%. man-made fibres are basically synthetic fibres based on petrochemicals that dominate the market: polyester (72%), cellulosic, acrylics, polypropylene, polyamide, and elastane (28%). chemicals industry needs to prepare synthetic monomers and polymers according to the chemical, physical and performance characteristics demanded by the textile & clothing (t/c) industry.  
bio-mass is the only source of bio-based chemical for bio-based synthetic textile fibres. nowadays there is an increasing need of bio-based chemicals such as ff (furfural) and hmf (hydroxymethyl furfural) from renewable, natural and non-edible vegetal raw materials.  
the socio-economic downturn of the european t/c and fibres industries is due to imported finished products. the end of trade agreement on textiles and clothing in 2005 resulted in no restrictions to foreign imports into the eu. this rapid growth in cheap imports of finished product is forcing european textile smes to close down.  
innovations like high added value and bio-based synthetic fibres produced by eco-efficient european processes are the required solution for a regain of competitive advantage against the current economic downturn. ecolastane bio-based synthetic fibres are derived from renewable resources (70% to 100% bio-based), are biodegradable and will have an increased (high & bio-based) quality as well as competitive price ratio against low-quality / cheap foreign imports from asia.  
the main limitations of current bio-based synthetic fibres are:  
â¢ lignocellulose is difficult to transform to bio-based monomers.  
â¢ ff production from the hemicellulosic part of lignocellulose is unprofitable in europe due to: loss of ff by deficient extraction, inefficient energy consumption, poor ff purification, inefficient solvent recovery, etc. on the other hand, the technologies used to synthesize ff are only available starting from hemicellulose pentoses (20-40% of lignocellulose); i.e. they cannot valorise cellulose (30-50 %).   
â¢ the industrial production costs of hmf are quite high.   
in conclusion, there are very few bio-based synthetic polymers available in the market and they are of low quality and high price.   
the ecolastane solution addresses the following needs:   
â¢ reduce the processing costs of lignocellulosic biomass. a wide range of processable biomass types will reduce dependence on the price and availability of only one feedstock. by a versatile and inexpensive drying and / or milling pre-treatment, a very small particle size is obtained to increase product yield of subsequent operations. moreover, during the pre-treatment, ground biomass is subject to an acid-free hemicellulose hydrolysis with the subsequent isolation of pentoses. lignin is removed from the remaining material in order to isolate free glucoses from hydrolysed cellulose. isolation of precursors increases the yield by avoiding side-reactions with lignin.   
â¢ furfural is produced from pentoses by an optimised version of the current process for a broad acceptance of our ecolastane technology. a quick furfural extraction prevents furfural loss by fragmentation reactions, and low energy-intensive gas-liquid absorption reduces purification costs.   
â¢ hmf is synthesized from hexoses in polar aprotic solvents in scalable conditions, and in this form ecolastane can develop an industrially feasible production of hmf.  
with these two compounds (ff and hmf) we have developed price-competitive 100% bio-based monomers (thf, fdca). finally, these bio-based monomers, resembling todayâs petrochemical structures, are combined into bio-based synthetic polymers of high performance and quality for textile fibres (70% bio-based commercial elastane and new polyester and elastanes with improved structures and performance industrially validated for textile uses). in the end, in ecolastane we have developed price-competitive and novel bio-based fibres with improved physico-chemical performance.   
in that sense, the ecolastane project will provide the european sme-based biomass sector with a modern high-yield and eco-efficient process to prepare price-competitive ff, hmf and thf from valorised waste. the objective is to turn this european industry into a competitive global scenario by expanding its target market, using these chemicals as suitable monomers for synthetic textile fibres and opening a new route for the industrial production of highly valuable bio-chemicals.  
  
project context and objectives:  
the industrial process of ecolastane is presented in figure 1 while the development process, from the raw materials to the finished fibres, can be summarised in the following phases:  
â¢ selecting and characterizing the best group of raw materials based on chemical studies, testing and / or developing different pre-treatments and particle sizes and testing the rheological behaviour of the mixture in the reactor.  
â¢ developing an improved bio-furfural (ff) synthesis with higher yields and lower costs.  
â¢ developing an innovative industrial bio-hydroxymethylfurfural (hmf) synthesis.  
â¢ our novel ecolastane fibres (elastanes from bio-ff, and polyesters from bio-ff and bio-hmf) have been designed with the necessary polymer chemical studies and trials in order to come up with the chemical structures showing the best performance, which required intensive laboratory work.  
1.1.3 scientific and technical objectives.  
ecolastane addressed the following scientific objectives:   
1. lignocellulosic biomass: to understand how seasonal quantitative availability, chemical composition, market value, transportation costs affect biomass raw materials.  
2. pre-treatment and extraction: to study the effects of eh mechanical, chemical and physical pre-treatments on biomass processing costs. evaluate the efficiency of hemicellulose hydrolysis into pentoses and cellulose into hexoses.  
3. synthetic fibre polymers: to understand the way in which key polymer functional groups, soft/hard segment proportion, chain length, cross-linking and additives contributes to the final performance of the material in the extruded monofilament.  
4. hmf (5-hydroxymethyl-2-furaldehyde) synthesis: to understand how glucose isomerization to fructose; fructose to hmf; conversion mechanism, different acid catalysts, yield-loss side reactions, and reaction conditions affect hmf synthesis.   
5. bio-tar: to study its chemical composition, rheological behaviour, the effect of different and burning conditions on the calorific power in order to identity the most appropriate parameter for in-plant combustion for a high efficiency heat release.  
6. synthetic fibers: to study novel chemical structures of polyester and polyamide fibres; extrusion, drawing and texturing operations on filaments; and behaviour, applications of novel bio-based ecolastane fibres for sports and leisure products.   
ecolastane addressed the following technical objectives:   
1. biomass-pre-treatment: pre-treatment to reduce lignocellulosic waste grinding biomass from #80 to #120 mesh.  
2. pentose and hexose extraction: efficient hydrolysis of hemicellulose pentoses preventing the synthesis of ff and preserving cellulose. the aim is the obtaining of solutions 95% rich in pentose and 95% hexose from selected biomass.  
3. hmf synthesis from lignin-free cellulose/hexoses extract. estimation of reaction kinetics. conceptual design of hmf reactor using computational fluid dynamics (cfd) models.  
4. bio-tetrahydrofuran (thf): synthesis of 100% bio-based thf from furfural by catalysed oxidation, subsequent decarboxylation and followed by metal-catalysed hydrogenation.  
5. bio-tar: production of a sample of bio-tar from lignin and by-products from ff and hmf synthesis and purification residues with a calorific power higher than the original material.   
6. synthetic fibre plastics polymer: bio-based elastane and polyester will be synthetized by extension of corresponding prepolymers.  
7. ff (furfural) purification and organic solvent recovery: 98% pure furfural for synthesis uses will be isolated by hetero-azeotropic distillation. organic solvents recovered by absorption.  
8. hmf purification: 99% pure hmf.  
9. prototype: continuous operation prototype at approx. 4l scale for furfural synthesis. conceptual design of hmf reactor using cfds models. up-dated bio-thf synthesis.  
10. validated ecolastane products. samples of formulated polymer chips and extruded and spun synthetic fibre monofilament of 70% bio-based elastane and 100% bio-based polyester.  
  
project results:  
the outcome of the ecolastane project can be measured in terms of its five main methods or results:  
1. furfural production method from lignocellulose.  
2. hmf production method from lignocellulose.  
3. bio-thf production method from lignocellulose.  
4. method for the production of novel bio-based polyester-like synthetic textiles fibres.  
5. method for the production of novel bio-based elastane synthetic textile fibres.  
  
furfural production method from lignocellulose.  
the current furfural production is still based on modified processes of the original quarker oats process (1953). this process mostly consist of suitable reactors loaded with acid-impregnated biomass, where steam is injected through the biomass bed at an optimal pressure and temperature, while a furfural enriched vapour stream is continuously retired. the furfural-containing stream is subsequently concentrated via azeotropic distillation and rectified via vacuum distillation which demands high energy. the solid biomass residues are normally incinerated or disposed of to take benefit of the energy in the process. this whole process runs in batch mode.  
   
the disadvantages of current technology are low yields (around 50% respect to xylose content) and high energy demanding purification, which means significant economic and environmental concerns. all these reasons contributed to shrink the furfural production capacity in eu downing to an only limited presence, and hindering the expansion and modernization of the furfural industry below its actual potential. a key objective in ecolastane was to improve current furfural (ff) yield in order to give solution to existing production and economical concerns. the idea was to avoid the production of resins derivated from the formation of ff inside the reactor. ecolastane provides a novel and alternative technology which is capable of enhancing the total production of furfural into 11% that means 3% more than classical technology. the ecolastane technology for furfural production is based on 4 stages:   
1. physic-chemical pre-treatment  
2. furfural production  
3. solvent extraction  
4. organic solvent recovery.  
  
hmf production method from lignocellulose.  
the production of bio-based furfural utilizes only a small fraction of the biomass and, in particular, only the hemicellulose. consequently, the remaining biomass which contains glucose and lignin is discarded as a waste and / or burned. however, the increased cellulose concentration of this material makes it a good candidate for the synthesis of other bio-based chemicals such as hmf.   
within the scope of the ecolastane project was the development of a process that could utilize this hemicellulose-free biomass for the synthesis of hmf, thereby creating a side-stream production process in order to increase the biomass utilization and offer additional economic benefits thus aiming to renew the interest of industry in eu for the synthesis of bio-based chemicals. towards this end, in ecolastane we studied the conditions for cellulose hydrolysis and concluded with the optimum ones for obtaining a glucose rich solution that was further used for the synthesis of hmf. in the next step, a new catalyst was synthesized and applied for the direct synthesis of hmf from the glucose rich solution. an intermediate isomerization step between glucose and fructose (in view of enhancing the hmf yield) was also investigated. finally a four step extraction process was developed, minimizing the use of chlorinated solvents, which are the current state-of-the-art for the hmf purification. consequently, the technology proposed for hmf synthesis could be summarized as follows:  
1. hydrolysis of cellulose from the hemicellulose-free biomass.  
2. conversion of glucose to hmf over heterogeneous catalyst.  
3. solvent extraction of hmf.  
4. hmf purification.  
the process has a 31% yield of hmf based on the glucose rich solution which corresponds to an overall yield of 4.8% based on hemicellulose-free biomass.  
   
bio-thf from lignocellulose.  
ff is converted to bio-thf by an up-dated industrial method. our bio-thf is chemically identical to petrochemical thf and thus does not require any different technology to produce a 100% bio-based ptmeg. this elastic diol accounting for ca 70% of the mass of commercial elastane fibres. using these bio-based diols we obtain 70% bio-based elastane fibres with unchanged chemistry and performance compared to petrochemical alternatives which is made possible thanks to our ecolastane bio-thf.  
  
novel bio-based polyester-like synthetic textiles fiber.  
new 100% bio-based polyester have been synthesized with a chemical structure resembling commercial polyester pbt. starting from bio-5-hmf it has been produced furan dicarboxylic acid (fdca), a real bio-based monomer alternative to terephtalic acid (pta) used in commercial polyester. on the other hand, a diol monomer, bio-butanediol (bdo) has been obtained from bio-thf, prepared in a previous step from furfural (ff). afterwards, an optimized strategic method for synthetizing polybutylene- furanoate (pbf), a 100% bio-based new polyester, has been developed using the ester derivate of the previous fdca and the butanediol (bdo). in a later process 100 % bio-fibres with very good properties and textile sample products were also produced.   
   
novel bio-based elastane synthetic textile fiber.  
on a basis of the highest performance / price ratio, two novel elastane structures have been developed by using ecolastane monomers and derivates. 70% bio-based elastane (polyurethane polyurea polymer), with chemical structure and performance equivalent to petrochemical fibres, was produced by employing long chain diols such as polytetramethyleneglycol (ptmeg, 70% of final elastane fiberâs weight). these materials were obtained from 100% renewable lignocellulose sources (bio-thf) and diphenylmethane-4.4-diisocyanate (mdi) and ethylene-diamine (eda).  
  
potential impact:  
expected final results.  
virtually all companies of the t/c and man-made fibres could potentially benefit from our ecolastane elastane and polyester. the price of our 70% bio-based elastane will successfully compete with todayâs petrochemical alternatives without demanding a change of current technologies. elastane is an elastic fibre present in small amounts in almost all types of fabrics. it is a fibre that can be spun with other fibres to produce unique textiles. all downstream textile products, especially sports clothing, backpacks, hydration devices, tents, accessories and miscellaneous will have the high added value given by our high-quality ecolastane fibres from renewable materials. these two features will render them more attractive for the final individual consumer against low-quality and low added-value foreign imports on the basis of a more favourable high-green quality / price ratio. bio-based products will give european producers an advantage-novel functionality, green credentials.   
on the other hand, the chemicals industry will directly benefit from our solution by having access to secure, non-petrochemical and abundant european sources of inexpensive and 100 % bio-based thf to satisfy the demand of elastane of man-made fibres industry. the major use of thf is as a monomer in the production of ptmeg, and secondarily as a solvent for multiple uses (solvent for oil cracking furfural alcohol for furan resins in metal casting industry, plastic manufacture, laboratory solvents, coating formulation additives, vulcanization catalyst and production of pesticides). in turn, around 80% of ptmeg goes to elastane fibres. our thf will be cheaper than similar products thanks to the use of lignocellulosic low-value raw materials and an eco-efficient technology for its production; thus saving energy and waste disposal costs as well as solvent input. our hmf production method from lignocellulose will be used for the production of fdca (furan dicarboxylic acid), for the synthesis of synthetic polymers for textiles fibres with a wide range of different fine chemicals; since hmf is a platform chemical for commodity chemicals. but the fact that our thf and hmf are a 100 % bio-based will translate into a more promising expansion in the market.   
biomass companies will see their technological obstacles overcome and will be provided with our ecolastane technology for preparing ff and hmf from a wide variety of lignocellulosic sources with a high yield, eco-efficient process, with low environmental energy and overall economic costs. ecolastane is in line with the strong wind in favour of environmental sustainability worldwide and the foreseen new legislations promoting the usage of bio-based plastics and sustainable materials. for bio-based plastics the price comparison is also favourable against conventional oil-based polymers, as crude oil prices will keep increasing.   
  
the ecolastane consortium.  
ecolastane is a project put forward by three european sme associations: techtera (technical textiles rhã´ne-alpes, france); amiq (asociaciã³n murciana de industrias quã­micas, spain); and czbiom (cz biomâczech biomass association, czech republic). we share a common value chain connecting final textile fibres (textile and clothing industry) with its starting bio-materials (biomass sme companies) through the intermediate transformation of bio-materials to bio-based synthetic fibres (chemicals industry).   
the consortium also counts with the participation of nutrafur; due to its 50-year experience in furfural production. the role of nutrafur was to validate at industrial scale the novel technology developed for converting vegetal matter to furfural and hmf. another important contribution comes from meyer. meyer assumed the vital role of validating elastane fibres (70% bio-based and identical-to-petrochemical elastane); as well as new bio-based polyester fibres. at the end of the supply chain we have raidlight. raidlight acted as the end-user in charge of validating the use of new textile fibres in real products. they evaluated the use of elastane and polyester fibres to produce woven textiles that can be used in the textile and cloth industry.   
the core of the scientific and technical work was developed by three reputed research organizations: tecnologã­as avanzadas inspiralia (insp), tã©cnicas reunidas (tr) and the centre for research and technology hellas (certh). tr developed the ecolastane technology for bio-based monomers, particularly the development of the ff production method working on the industrial pre-treatment of biomass and on the pentose production process towards the production of furfural (furfural purification, recovery of solvents, etc.). certh was chosen for the key role of developing an industrially feasible technology for preparing hmf as one of ecolastane bio-based monomers. certh did the biomass selection, hexose extraction from cellulose and bio-tar preparation and characterization. moreover they performed the synthesis and the design of the correspondent hmf reactor. certh conducted a full analysis of the costs and scalability of ecolastane technology. inspiralia applied their expertise in the area of material chemistry, polymer science, formulation and mechanical analysis to lead the tasks dealing with the synthesis of ecolastane elastane and polyester fibres (monomer functionalization and synthesis, prepolymers synthesis and polymer synthesis). they formulated and characterized the final plastics polymers. inspiralia worked alongside meyer and raidlight in the validation of ecolastane fibres and performed the simulations leading to the design of the hmf reactor.  
  
list of websites:  
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fax: + 33 420 302889   
e-mail: info@techtera.org  
  
project website: www.ecolastane.eu

# ECOLASTANE

Project Acronym: ECOLASTANE

programme & topic: FP7-SME SME-2012-2

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â¢ developing an improved bio-furfural (ff) synthesis with higher yields and lower costs.  
â¢ developing an innovative industrial bio-hydroxymethylfurfural (hmf) synthesis.  
â¢ our novel ecolastane fibres (elastanes from bio-ff, and polyesters from bio-ff and bio-hmf) have been designed with the necessary polymer chemical studies and trials in order to come up with the chemical structures showing the best performance, which required intensive laboratory work.  
1.1.3 scientific and technical objectives.  
ecolastane addressed the following scientific objectives:   
1. lignocellulosic biomass: to understand how seasonal quantitative availability, chemical composition, market value, transportation costs affect biomass raw materials.  
2. pre-treatment and extraction: to study the effects of eh mechanical, chemical and physical pre-treatments on biomass processing costs. evaluate the efficiency of hemicellulose hydrolysis into pentoses and cellulose into hexoses.  
3. synthetic fibre polymers: to understand the way in which key polymer functional groups, soft/hard segment proportion, chain length, cross-linking and additives contributes to the final performance of the material in the extruded monofilament.  
4. hmf (5-hydroxymethyl-2-furaldehyde) synthesis: to understand how glucose isomerization to fructose; fructose to hmf; conversion mechanism, different acid catalysts, yield-loss side reactions, and reaction conditions affect hmf synthesis.   
5. bio-tar: to study its chemical composition, rheological behaviour, the effect of different and burning conditions on the calorific power in order to identity the most appropriate parameter for in-plant combustion for a high efficiency heat release.  
6. synthetic fibers: to study novel chemical structures of polyester and polyamide fibres; extrusion, drawing and texturing operations on filaments; and behaviour, applications of novel bio-based ecolastane fibres for sports and leisure products.   
ecolastane addressed the following technical objectives:   
1. biomass-pre-treatment: pre-treatment to reduce lignocellulosic waste grinding biomass from #80 to #120 mesh.  
2. pentose and hexose extraction: efficient hydrolysis of hemicellulose pentoses preventing the synthesis of ff and preserving cellulose. the aim is the obtaining of solutions 95% rich in pentose and 95% hexose from selected biomass.  
3. hmf synthesis from lignin-free cellulose/hexoses extract. estimation of reaction kinetics. conceptual design of hmf reactor using computational fluid dynamics (cfd) models.  
4. bio-tetrahydrofuran (thf): synthesis of 100% bio-based thf from furfural by catalysed oxidation, subsequent decarboxylation and followed by metal-catalysed hydrogenation.  
5. bio-tar: production of a sample of bio-tar from lignin and by-products from ff and hmf synthesis and purification residues with a calorific power higher than the original material.   
6. synthetic fibre plastics polymer: bio-based elastane and polyester will be synthetized by extension of corresponding prepolymers.  
7. ff (furfural) purification and organic solvent recovery: 98% pure furfural for synthesis uses will be isolated by hetero-azeotropic distillation. organic solvents recovered by absorption.  
8. hmf purification: 99% pure hmf.  
9. prototype: continuous operation prototype at approx. 4l scale for furfural synthesis. conceptual design of hmf reactor using cfds models. up-dated bio-thf synthesis.  
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project results:  
the outcome of the ecolastane project can be measured in terms of its five main methods or results:  
1. furfural production method from lignocellulose.  
2. hmf production method from lignocellulose.  
3. bio-thf production method from lignocellulose.  
4. method for the production of novel bio-based polyester-like synthetic textiles fibres.  
5. method for the production of novel bio-based elastane synthetic textile fibres.  
  
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1. physic-chemical pre-treatment  
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the production of bio-based furfural utilizes only a small fraction of the biomass and, in particular, only the hemicellulose. consequently, the remaining biomass which contains glucose and lignin is discarded as a waste and / or burned. however, the increased cellulose concentration of this material makes it a good candidate for the synthesis of other bio-based chemicals such as hmf.   
within the scope of the ecolastane project was the development of a process that could utilize this hemicellulose-free biomass for the synthesis of hmf, thereby creating a side-stream production process in order to increase the biomass utilization and offer additional economic benefits thus aiming to renew the interest of industry in eu for the synthesis of bio-based chemicals. towards this end, in ecolastane we studied the conditions for cellulose hydrolysis and concluded with the optimum ones for obtaining a glucose rich solution that was further used for the synthesis of hmf. in the next step, a new catalyst was synthesized and applied for the direct synthesis of hmf from the glucose rich solution. an intermediate isomerization step between glucose and fructose (in view of enhancing the hmf yield) was also investigated. finally a four step extraction process was developed, minimizing the use of chlorinated solvents, which are the current state-of-the-art for the hmf purification. consequently, the technology proposed for hmf synthesis could be summarized as follows:  
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2. conversion of glucose to hmf over heterogeneous catalyst.  
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4. hmf purification.  
the process has a 31% yield of hmf based on the glucose rich solution which corresponds to an overall yield of 4.8% based on hemicellulose-free biomass.  
   
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new 100% bio-based polyester have been synthesized with a chemical structure resembling commercial polyester pbt. starting from bio-5-hmf it has been produced furan dicarboxylic acid (fdca), a real bio-based monomer alternative to terephtalic acid (pta) used in commercial polyester. on the other hand, a diol monomer, bio-butanediol (bdo) has been obtained from bio-thf, prepared in a previous step from furfural (ff). afterwards, an optimized strategic method for synthetizing polybutylene- furanoate (pbf), a 100% bio-based new polyester, has been developed using the ester derivate of the previous fdca and the butanediol (bdo). in a later process 100 % bio-fibres with very good properties and textile sample products were also produced.   
   
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on a basis of the highest performance / price ratio, two novel elastane structures have been developed by using ecolastane monomers and derivates. 70% bio-based elastane (polyurethane polyurea polymer), with chemical structure and performance equivalent to petrochemical fibres, was produced by employing long chain diols such as polytetramethyleneglycol (ptmeg, 70% of final elastane fiberâs weight). these materials were obtained from 100% renewable lignocellulose sources (bio-thf) and diphenylmethane-4.4-diisocyanate (mdi) and ethylene-diamine (eda).  
  
potential impact:  
expected final results.  
virtually all companies of the t/c and man-made fibres could potentially benefit from our ecolastane elastane and polyester. the price of our 70% bio-based elastane will successfully compete with todayâs petrochemical alternatives without demanding a change of current technologies. elastane is an elastic fibre present in small amounts in almost all types of fabrics. it is a fibre that can be spun with other fibres to produce unique textiles. all downstream textile products, especially sports clothing, backpacks, hydration devices, tents, accessories and miscellaneous will have the high added value given by our high-quality ecolastane fibres from renewable materials. these two features will render them more attractive for the final individual consumer against low-quality and low added-value foreign imports on the basis of a more favourable high-green quality / price ratio. bio-based products will give european producers an advantage-novel functionality, green credentials.   
on the other hand, the chemicals industry will directly benefit from our solution by having access to secure, non-petrochemical and abundant european sources of inexpensive and 100 % bio-based thf to satisfy the demand of elastane of man-made fibres industry. the major use of thf is as a monomer in the production of ptmeg, and secondarily as a solvent for multiple uses (solvent for oil cracking furfural alcohol for furan resins in metal casting industry, plastic manufacture, laboratory solvents, coating formulation additives, vulcanization catalyst and production of pesticides). in turn, around 80% of ptmeg goes to elastane fibres. our thf will be cheaper than similar products thanks to the use of lignocellulosic low-value raw materials and an eco-efficient technology for its production; thus saving energy and waste disposal costs as well as solvent input. our hmf production method from lignocellulose will be used for the production of fdca (furan dicarboxylic acid), for the synthesis of synthetic polymers for textiles fibres with a wide range of different fine chemicals; since hmf is a platform chemical for commodity chemicals. but the fact that our thf and hmf are a 100 % bio-based will translate into a more promising expansion in the market.   
biomass companies will see their technological obstacles overcome and will be provided with our ecolastane technology for preparing ff and hmf from a wide variety of lignocellulosic sources with a high yield, eco-efficient process, with low environmental energy and overall economic costs. ecolastane is in line with the strong wind in favour of environmental sustainability worldwide and the foreseen new legislations promoting the usage of bio-based plastics and sustainable materials. for bio-based plastics the price comparison is also favourable against conventional oil-based polymers, as crude oil prices will keep increasing.   
  
the ecolastane consortium.  
ecolastane is a project put forward by three european sme associations: techtera (technical textiles rhã´ne-alpes, france); amiq (asociaciã³n murciana de industrias quã­micas, spain); and czbiom (cz biomâczech biomass association, czech republic). we share a common value chain connecting final textile fibres (textile and clothing industry) with its starting bio-materials (biomass sme companies) through the intermediate transformation of bio-materials to bio-based synthetic fibres (chemicals industry).   
the consortium also counts with the participation of nutrafur; due to its 50-year experience in furfural production. the role of nutrafur was to validate at industrial scale the novel technology developed for converting vegetal matter to furfural and hmf. another important contribution comes from meyer. meyer assumed the vital role of validating elastane fibres (70% bio-based and identical-to-petrochemical elastane); as well as new bio-based polyester fibres. at the end of the supply chain we have raidlight. raidlight acted as the end-user in charge of validating the use of new textile fibres in real products. they evaluated the use of elastane and polyester fibres to produce woven textiles that can be used in the textile and cloth industry.   
the core of the scientific and technical work was developed by three reputed research organizations: tecnologã­as avanzadas inspiralia (insp), tã©cnicas reunidas (tr) and the centre for research and technology hellas (certh). tr developed the ecolastane technology for bio-based monomers, particularly the development of the ff production method working on the industrial pre-treatment of biomass and on the pentose production process towards the production of furfural (furfural purification, recovery of solvents, etc.). certh was chosen for the key role of developing an industrially feasible technology for preparing hmf as one of ecolastane bio-based monomers. certh did the biomass selection, hexose extraction from cellulose and bio-tar preparation and characterization. moreover they performed the synthesis and the design of the correspondent hmf reactor. certh conducted a full analysis of the costs and scalability of ecolastane technology. inspiralia applied their expertise in the area of material chemistry, polymer science, formulation and mechanical analysis to lead the tasks dealing with the synthesis of ecolastane elastane and polyester fibres (monomer functionalization and synthesis, prepolymers synthesis and polymer synthesis). they formulated and characterized the final plastics polymers. inspiralia worked alongside meyer and raidlight in the validation of ecolastane fibres and performed the simulations leading to the design of the hmf reactor.  
  
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# ECOLASTANE

Project Acronym: ECOLASTANE

programme & topic: FP7-SME SME-2012-2

Most frequent returning words in objectives:

* ('fibres', 36)
* ('ecolastane', 32)
* ('production', 30)
* ('biomass', 23)
* ('synthesis', 23)
* ('elastane', 20)
* ('process', 15)
* ('textile', 14)
* ('technology', 14)
* ('polyester', 13)
* ('chemical', 12)
* ('industry', 11)
* ('lignocellulose', 11)
* ('novel', 11)
* ('method', 11)
* ('chemicals', 10)
* ('performance', 9)
* ('purification', 9)
* ('costs', 9)
* ('solution', 8)
* ('monomers', 8)
* ('materials', 8)
* ('products', 8)
* ('textiles', 8)

executive summary:  
ecolastane has been designed to overcome the technical obstacles preventing our value chain from addressing the common needs of bio-based chemicals and bio-based synthetic fibres as a technical solution providing the whole community with strengthened competitive advantage.  
around 25% of the fibres consumed in europe are natural (cotton, wool, silk), while man-made fibres represent 75%. man-made fibres are basically synthetic fibres based on petrochemicals that dominate the market: polyester (72%), cellulosic, acrylics, polypropylene, polyamide, and elastane (28%). chemicals industry needs to prepare synthetic monomers and polymers according to the chemical, physical and performance characteristics demanded by the textile & clothing (t/c) industry.  
bio-mass is the only source of bio-based chemical for bio-based synthetic textile fibres. nowadays there is an increasing need of bio-based chemicals such as ff (furfural) and hmf (hydroxymethyl furfural) from renewable, natural and non-edible vegetal raw materials.  
the socio-economic downturn of the european t/c and fibres industries is due to imported finished products. the end of trade agreement on textiles and clothing in 2005 resulted in no restrictions to foreign imports into the eu. this rapid growth in cheap imports of finished product is forcing european textile smes to close down.  
innovations like high added value and bio-based synthetic fibres produced by eco-efficient european processes are the required solution for a regain of competitive advantage against the current economic downturn. ecolastane bio-based synthetic fibres are derived from renewable resources (70% to 100% bio-based), are biodegradable and will have an increased (high & bio-based) quality as well as competitive price ratio against low-quality / cheap foreign imports from asia.  
the main limitations of current bio-based synthetic fibres are:  
â¢ lignocellulose is difficult to transform to bio-based monomers.  
â¢ ff production from the hemicellulosic part of lignocellulose is unprofitable in europe due to: loss of ff by deficient extraction, inefficient energy consumption, poor ff purification, inefficient solvent recovery, etc. on the other hand, the technologies used to synthesize ff are only available starting from hemicellulose pentoses (20-40% of lignocellulose); i.e. they cannot valorise cellulose (30-50 %).   
â¢ the industrial production costs of hmf are quite high.   
in conclusion, there are very few bio-based synthetic polymers available in the market and they are of low quality and high price.   
the ecolastane solution addresses the following needs:   
â¢ reduce the processing costs of lignocellulosic biomass. a wide range of processable biomass types will reduce dependence on the price and availability of only one feedstock. by a versatile and inexpensive drying and / or milling pre-treatment, a very small particle size is obtained to increase product yield of subsequent operations. moreover, during the pre-treatment, ground biomass is subject to an acid-free hemicellulose hydrolysis with the subsequent isolation of pentoses. lignin is removed from the remaining material in order to isolate free glucoses from hydrolysed cellulose. isolation of precursors increases the yield by avoiding side-reactions with lignin.   
â¢ furfural is produced from pentoses by an optimised version of the current process for a broad acceptance of our ecolastane technology. a quick furfural extraction prevents furfural loss by fragmentation reactions, and low energy-intensive gas-liquid absorption reduces purification costs.   
â¢ hmf is synthesized from hexoses in polar aprotic solvents in scalable conditions, and in this form ecolastane can develop an industrially feasible production of hmf.  
with these two compounds (ff and hmf) we have developed price-competitive 100% bio-based monomers (thf, fdca). finally, these bio-based monomers, resembling todayâs petrochemical structures, are combined into bio-based synthetic polymers of high performance and quality for textile fibres (70% bio-based commercial elastane and new polyester and elastanes with improved structures and performance industrially validated for textile uses). in the end, in ecolastane we have developed price-competitive and novel bio-based fibres with improved physico-chemical performance.   
in that sense, the ecolastane project will provide the european sme-based biomass sector with a modern high-yield and eco-efficient process to prepare price-competitive ff, hmf and thf from valorised waste. the objective is to turn this european industry into a competitive global scenario by expanding its target market, using these chemicals as suitable monomers for synthetic textile fibres and opening a new route for the industrial production of highly valuable bio-chemicals.  
  
project context and objectives:  
the industrial process of ecolastane is presented in figure 1 while the development process, from the raw materials to the finished fibres, can be summarised in the following phases:  
â¢ selecting and characterizing the best group of raw materials based on chemical studies, testing and / or developing different pre-treatments and particle sizes and testing the rheological behaviour of the mixture in the reactor.  
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the ecolastane consortium.  
ecolastane is a project put forward by three european sme associations: techtera (technical textiles rhã´ne-alpes, france); amiq (asociaciã³n murciana de industrias quã­micas, spain); and czbiom (cz biomâczech biomass association, czech republic). we share a common value chain connecting final textile fibres (textile and clothing industry) with its starting bio-materials (biomass sme companies) through the intermediate transformation of bio-materials to bio-based synthetic fibres (chemicals industry).   
the consortium also counts with the participation of nutrafur; due to its 50-year experience in furfural production. the role of nutrafur was to validate at industrial scale the novel technology developed for converting vegetal matter to furfural and hmf. another important contribution comes from meyer. meyer assumed the vital role of validating elastane fibres (70% bio-based and identical-to-petrochemical elastane); as well as new bio-based polyester fibres. at the end of the supply chain we have raidlight. raidlight acted as the end-user in charge of validating the use of new textile fibres in real products. they evaluated the use of elastane and polyester fibres to produce woven textiles that can be used in the textile and cloth industry.   
the core of the scientific and technical work was developed by three reputed research organizations: tecnologã­as avanzadas inspiralia (insp), tã©cnicas reunidas (tr) and the centre for research and technology hellas (certh). tr developed the ecolastane technology for bio-based monomers, particularly the development of the ff production method working on the industrial pre-treatment of biomass and on the pentose production process towards the production of furfural (furfural purification, recovery of solvents, etc.). certh was chosen for the key role of developing an industrially feasible technology for preparing hmf as one of ecolastane bio-based monomers. certh did the biomass selection, hexose extraction from cellulose and bio-tar preparation and characterization. moreover they performed the synthesis and the design of the correspondent hmf reactor. certh conducted a full analysis of the costs and scalability of ecolastane technology. inspiralia applied their expertise in the area of material chemistry, polymer science, formulation and mechanical analysis to lead the tasks dealing with the synthesis of ecolastane elastane and polyester fibres (monomer functionalization and synthesis, prepolymers synthesis and polymer synthesis). they formulated and characterized the final plastics polymers. inspiralia worked alongside meyer and raidlight in the validation of ecolastane fibres and performed the simulations leading to the design of the hmf reactor.  
  
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# PROSYS-LASER

Project Acronym: PROSYS-LASER

programme & topic: FP7-NMP NMP-2008-4.0-9

Most frequent returning words in objectives:

* ('laser', 123)
* ('systems', 34)
* ('passive', 29)
* ('protection', 27)
* ('skin', 26)
* ('clothing', 24)
* ('irradiation', 22)
* ('protective', 22)
* ('radiation', 21)
* ('project', 19)
* ('material', 19)
* ('processing', 18)
* ('textile', 18)
* ('time', 18)
* ('order', 18)
* ('system', 18)
* ('curtains', 17)
* ('accidents', 17)
* ('figure', 17)
* ('sensor', 16)
* ('multi-layer', 15)
* ('safety', 15)
* ('properties', 13)
* ('respect', 13)

executive summary:  
1. executive summary  
prosys-laser was dedicated to developing highly innovative passive and active (âsmartâ) laser-protective clothing and curtains for use with hand-held laser processing devices (hlds) and with automated laser machines. using such laser-protective clothing and curtains, the skin of the machine operator as well as of any person in the neighbourhood of the laser process shall be protected against accidental laser irradiation. especially adequate laser-protective clothing is hardly available on the market today.  
the major project objectives were:  
â¢ to open new markets for high-performance laser-protective clothing and curtains as well as for the testing procedure, especially encouraging participating smes to widen their product range and to directly benefit from the project developments and prototypes,   
â¢ to sustain the growth of laser technology by providing means for the safe use of innovative technological developments such as hand-held laser devices for material processing and high power lasers with high brightness, to minimise health risks for the operators of hlds and automated laser machines, and consequently to reduce the number of related accidents,   
â¢ to contribute to the standardisation process considering laser-protective clothing and the corresponding testing procedures.  
  
the approach to achieve these objectives was to combine innovative laser technology with high performance textile technology. key developments were:  
â¢ passive functional multi-layer technical textiles, providing a high level of passive laser resistance,   
â¢ active functional multi-layer textiles incorporating sensors that detect laser exposure and are, by means of a safety control, able to deactivate the laser beam automatically,   
â¢ test methods and testing setups to qualify passive and active functional technical textiles and tailored laser-protective clothing, respectively.  
  
for the planned work, a consortium of 13 european partners, 9 of them being smes and 3 of them being research institutions, was founded, representing a goal-oriented combination of the competencies and skills required for a successful project progress and at the same time showing the great relevance of the topic for the sme sector.  
  
based on the textile systems developed, prototypes for passive and active gloves, jackets and aprons, as well as for active curtains were manufactured, the active systems connected to adequate electronics. in this context, properties such as wear resistance, inflammability and washability, as well as haptics and ergonomic aspects were taken into account. in addition, a specific testing rig was developed, incorporating instrumentation for the automated measurement of optical and thermophysical properties upon defined laser irradiation, in order to evaluate the laser-protective performance of the new passive and active textile systems. the results of these developments have been used to initiate the standardisation of the laser-protective textile testing procedure, which will later be the basis for the standardisation of the laser-protective clothing and curtains in terms of amendments of existing european standards or of completely new standards.  
  
for the exploitation of the project developments, 14 exploitable results have been defined, for which the partners will conclude contracts in order to achieve a close and successful cooperation after the project end. the market launch of the new passive and active laser-protective clothing and of the active curtains is expected within 2013.  
  
project context and objectives:  
2. project context and objectives  
2.1. technical background considering laser material processing  
lasers for material processing are mainly used as part of automated production systems. these laser machines are often closed (class 1 according to en 60825-1:2007 [1]), however, a class 4 laser is in operation inside the machine. under standard working conditions, these class 1 systems are safe due to housing and safety interlock circuits that switch off the laser source automatically upon opening the housing. in case of maintenance, service personnel may work under class 4 conditions. therefore, the safety interlocks have to be bridged. here, a notable risk of injury by accidental laser irradiation exists. the radiation is able to damage human tissues seriously, depending on the power density on the irradiated surface. this is not only relevant for the protection of the human eyes, for which adequate personal protective equipment (ppe) exists on the market in terms of laser goggles to be able to meet the maximum permissible exposure for the eye (mpeeye), but also for the protection of the human skin, for which the maximum permissible exposure (mpeskin) can be found in [1,2] as well, however almost no adequate ppe is available.  
hand-held laser processing devices (hlds) represent a niche application in the field of industrial laser material processing. such hand-held systems provide a high degree of freedom and thus a significantly higher potential risk considering the exposition to laser radiation. this means that the hld operator often works under class 4 conditions. in contrast to the typical usage of automated systems, the laser system user is specifically trained and knows about the potential risks of laser radiation. safety shielding and sensors reduce the risk of injury to a minimum. however, the risk of irradiating the skin either by the direct beam (binocular working station) or the reflected beam remains. such risks occur as well if persons have to work close to automated âconventionalâ laser processes which are not housed due to different reasons.  
there are two approaches to protect the human skin against the physiological effects of laser irradiation, which are both considered in the following:   
â¢ passive protection by means of materials or material combinations   
that provide a high level of passive laser resistance   
â¢ active protection by means of materials incorporating sensors   
that detect laser exposure and are, by means of a safety control,   
able to deactivate the laser beam automatically   
  
2.2. normative background considering laser-protective clothing  
to protect humans against accidental laser irradiation, comprehensive regulations and standards exist. based on the european standard en 60825-1 and on the eu directive 2006/25/ec [1,2], power density thresholds were defined to allow the allocation of laser systems to different classes as a function of the foreseeable exposure (foreseeable exposure limits â fels), and to ensure protection of the human eye and skin by taking technical, organisational or personal measures (maximum permissible exposures â mpeeye and mpeskin values). considering the protection of the operators' eyes against incident laser radiation, suitable eyewear of different producers exists with protection levels adapted to specific wavelength ranges and power density levels. the usage of such laser goggles is a standard procedure in industry, but also in scientific institutions dealing with laser radiation. this situation is completely different as far as the protection of the human skin is considered. only a few more or less common recommendations can be found regarding the type of clothing to be worn, e.g. concerning low flammability (see din en iso 11611 [3] and din en iso 11612 [4]). however, rules or standards which define the requirements concerning laser-protective clothing (laser ppe, in the following ppe referred to without equipment for eye protection) as well as standardised measurement methods and testing procedures suitable to reproducibly assess laser ppe do not exist. whenever laser ppe is needed, protective clothing originally produced for other industrial sectors is used, e.g. clothing for welders. there is almost no certified laser ppe available on the market, although the consequences of skin injuries caused by intenâ¬sive laser radiation are definitely serious: laser radiation emitted in the near-infrared (nir) range has a rather large depth of penetration into the human tissue and is mainly absorbed in deeper regions at blood vessels or bones. due to the heat released during the laser-tissue interaction, organic material below the upper skin layers is damaged or even evaporated to a notable extent, what may result in rather serious, painful, and interminable injuries [1,5,6,7,8].  
  
2.3. accidental background considering laser injuries  
regarding the turnover of about 7.2 billion euros (in 2011) for laser sources and laser processing machines worldwide in the field of industrial material processing, the high relevance of laser technology for the whole field of material processing is obvious. taking into account the whole machine tool market, the worldwide turnover amounted to about 62 billion euros in 2011. thus, the market for laser material processing is about one eighth of the machine tool market, what is a remarkable value. one of the global market leaders for lasers and laser systems is trumpf gmbh + co. kg, notable competitors are e.g. coherent, inc., rofin-sinar laser gmbh, ipg laser gmbh, newport corporation, and laserline gmbh.  
for conventional non-laser applications which are more or less dangerous, diverse regulations and standards for the testing and selection of proper ppe already exist since a long time, what is enforcing the prevention of accidents. consequently, the number of accidents with serious injuries is reduced by the usage of adequate ppe.  
as already described, such regulations only do not exist considering the protection of the human skin.  
a main problem regarding the argumentation for laser ppe is that the number of laser accidents concerning the workers' skin cannot be specified exactly. such accidents are often classified as e.g. conventional burnings or accidents caused by faulty machine controls, i.e. they are not allocated to the category of laser accidents at all.  
recent information of the german employers' liability insurance association [9] indicates a number of about 15 laser accidents in germany during 6% of the yearly working days. this number includes injuries not only of the skin, but also of the eyes. the extrapolation to one working year yields a number of 250 accidents. however, only notifiable accidents characterised by at least three days of absenteeism from work, are recorded. the number of unreported cases, i.e. of accidents with less severe injuries and of near-accident cases, is probably much larger. therefore, the above information of the german employers' liability insurance association can only lead to a very rough estimation of the real number of laser accidents concerning the workers' skin.  
nevertheless, it is assumed for this estimation that one tenth of the total number of recorded laser accidents concerns skin injuries. furthermore, it is assumed that 75% of all laser accidents are allocated to other categories of accidents, e.g. conventional burnings, accidents by faulty machine controls, etc. dividing by 10 and multiplying by 4 yields a number of about 100 laser accidents of the skin in germany per year. assuming that only 10% of all cases are reported, the number of risk situations would amount to about 1,000 cases per year. this is a really remarkable value, particularly as only the german industry is regarded. based on a rough research, there are up to 1,000 laser job-shops and comparable companies using laser systems for material processing in germany. this means that on average, one laser accident concerning the skin will happen per year in each laser company in germany with high probability.  
  
apart from the laser wavelength, the hazardous potential of hand-held laser devices or automated non-closed laser machines is strongly dependent on the distance of the potentially irradiated part of the human skin to the processing zone. the reason is that the intensity of focused laser radiation increases with the square of the decreasing distance to the processing zone. a typical situation which occurs to the operators standing next to the processing zone during hld use, and the corresponding distances from the processing zone to the different parts of the human body are shown in figure 1. according to this illustration, the most endangered body parts are the hands that operate the hld.  
  
in principle, three types of laser irradiation can be distinguished: irradiation by a diffusely reflected beam, irradiation by a directly reflected beam, and direct irradiation. according to this listing, the safety level required with respect to skin protection increases form left to right in figure 2.  
with respect to the dimensioning of laser ppe and curtains, the worst case has to be taken into account. mostly, hlds are equipped with safety systems, e.g. two-hand control buttons or contact pins, which should avoid direct irradiation by a focused laser beam.  
  
2.4. main project objectives  
the situation described above was the motivation for the work presented in this report. consequently, the main objective of the prosys-laser project was to combine innovative laser techâ¬nology with high performance textile technology in order to develop adequate passive and active protective clothing for the protection of the human skin against accidental laser irradiation and of adequate active protective curtains. here, the passive systems consist of functional multi-layer technical textiles, providing a high level of passive laser resistance. in addition, the active functional multi-layer textiles incorporate sensors that detect laser exposure and are, by means of a safety control, able to deactivate the laser beam automatically.  
due to the lack of regulations for testing and qualifying laser-protective textiles used as laser ppe, test methods were defined and validated. additionally, corresponding testing set-ups were developed.  
finally, the gap with respect to standardisation was bridged by the definition of a test procedure and the requirements with respect to laser ppe.  
the project developments were demonstrated by a set of tailored functional passive and active laser-protective clothing prototypes (gloves, jackets, aprons, trousers) and active curtains as well as by a prototype testing rig, providing the possibility to perform the specified low-power and high-power textile test procedure.  
  
project results:  
3. main project results  
3.1. passive laser-protective systems  
passive laser ppe serves as a kind of screen in order to protect the worker's skin directly under the clothing against incident laser radiation for as long as possible. however, the user of the laser-protective clothing must be enabled to remove the irradiated body part from the hazard area before a second degree burn occurs. therefore, the person concerned must be able to percept the effect of the laser radiation, i.e. the pain caused.  
stoll and chianta developed mathematical models for the onset of a 2nd degree burn (blister formation) by applying a 95% statistical probability. these models can be used flexibly for different energy types (flame, heat radiation, heat conduction) interacting with the human skin. in figure 18, the onsets of pain (first stimulus) and of 2nd degree burn (blister formation) are illustrated as a function of the heat flux and the exposure time (tolerance time of the unprotected skin) [10,11], see section 3.5.2.  
in this illustration, the reaction time, i.e. the time available to remove the affected body part from the hazard area before a 2nd degree burn occurs, is the time span between the intersections of the calorimetric measuring curve, giving the energy density flowing to the irradiated surface, with the stoll/chianta pain threshold curve on the one hand and the 2nd degree burn curve on the other hand. the bigger this time span, the more time has the affected person to react to the exposure. this time span should not be smaller than four seconds according to [12].  
  
this consideration results in the definition of the first main evaluation criterion, the so-called stoll/chianta criterion, for the qualification and assessment of the protective functionality of textile single or multi-layer systems to be used as laser ppe or curtain. the second criterion is an almost negligible transmissibility with respect to the laser wavelength used for the investigation, i.e. the transmitted power has to be smaller than the mpeskin value according to [1].  
  
in order to achieve an optimal protective functionality, the textile systems developed consist of one or more functional layers. as example, a 3-layers system is shown schematically in figure 3. in this construction, the outer layer is intended to reflect the incident radiation as good as possible. this reflection should be diffusive in order to prevent additional hazards for persons who stay near the processing zone.  
  
the function of the middle layer is to dissipate the part of the energy, which is not reflected, but transmitted or absorbed, over a larger surface area. therefore, the material should have a high scattering ability with respect to the transmitted laser radiation, as well as a high heat conductivity parallel to the surface. simultaneously, the remaining radiation should be absorbed to a large degree in order to minimise the energy transfer to the inner textile layer, which is adjacent to the skin, and thus to meet the mpeskin value.  
  
finally, the inner layer is an additional barrier for the energy incorporated into the system. correspondingly, the heat conductivity should be low. however, it has to be ensured that a small part of the energy can reach the skin in order to cause pain perception and the following movement reaction.  
  
3.2. active laser-protective systems  
in addition to a basic passive protective functionality, active laser-protective systems feature a possibility to deactivate the laser emission immediately in case of accidental irradiation. for this purpose, sensors are integrated into the multi-layer construction, generating an adequate electrical or optical signal upon irradiation, which is processed by a connected control unit.  
  
in general, such sensors may be designed as single-layer or multi-layer sensors. a possible setup is shown schematically in figure 4. the signal generation can either be based on a reversible or an irreversible effect: an irreversible change is easier to detect, but the sensor has to be repaired or exchanged afterwards.  
in the course of the project, two types of sensor systems for active laser ppe as well as for active laser-protective curtains were developed. the functionality of both sensor types is based on irreversible changes of the electrical properties.  
the first sensor is based on a wire that changes its electrical properties in case of a damage of the sensor structure (see figure 5, left).  
the second sensor variant consists of a multi-layer structure with conductive layers on the outer surfaces. in case of an irradiation, an electrical conduction is generated due to the melting of the layers (see figure 5, right).  
these sensors are integrated in the multi-layer structure in such a way that they are protected against mechanical influences as well as against a premature activation by very low (quasi non-dangerous) incident laser powers. furthermore, the layers below the sensor layer have to provide the ppe user with sufficient protection during the time span between the detection of accidental irradiation and the shutdown of the laser system until a safe condition is reached.  
  
finally, this dimensioning of the âpassiveâ protection as part of the active system is decisive for the high protection level of the whole system, meeting the two above-mentioned main evaluation criteria. however, weight and thickness of the textile construction are of particular importance for the usage of laser ppe with respect to wearing comfort and ergonomics (see section 3.3).  
  
to ensure a high degree of movement freedom and comfort for the ppe user, the electrical connection to the laser source is realised as a wireless connection.  
therefore, the sensors embedded into the textile structure are connected to a sensor unit (emitter, figure 6, left) which is linked to the safety unit (receiver, figure 6, right) via bluetooth. the safety unit is hardwired to the interlock of the laser source. this system can be used for active laser ppe, but also for curtains. the principle described here has been tested successfully for different sensor variants and a large range of laser powers. figure 7 shows as a scheme of the intended use of such active laser ppe and curtains to protect the operator as well as the persons which also stay in the hazard area.  
  
in order to provide maximal system reliability, a high robustness of the wireless communication has to be ensured. the specifications of this system have been defined in terms of system architecture, sensor block diagrams, and safety units, as well as the definition of the safety protocol layer. software programming and adaptation with respect to the specific requirements of the active concept regarded have been performed. the system is configured in such a way that the safety control does not release the laser radiation unless a control signal is received from the sensor unit, confirming the proper sensor function. if the sensors are hit by laser radiation of a sufficiently high intensity, the electrical properties are changed significantly which is detected by the sending unit and submitted to the safety control. thus, the laser can be switched off or the radiation can be blocked immediately.  
  
3.3. evaluation and assessment of potential laser-protective systems  
two main criteria for the qualification of laser ppe were identified (see above): the mzbskin value and the so-called stoll/chianta criterion have to be met.  
as secondary evaluation criteria, the results of the visual observation and assessment of the samples upon laser irradiation can be considered, e.g. showing the changes of the material structure in terms of hole formation, shrinkage, etc. an afterburning time of more than 2 seconds is not allowed according to [13]. furthermore, the textile multi-layer systems should be washable or cleanable without suffering a significant change of the specific optical and thermophysical properties in order to be useable as protective clothing against laser radiation successfully. in addition, the textile material combination should have a sufficient high temperature resistance.  
for the systematic and reproducible qualification of the laser-relevant properties mentioned, a specific testing setup was designed, which combines several optical and thermal measurement methods (see section 3.8). in particular, diffusive and specular remittance and transmittance of the material combination considered may be investigated for the laser wavelength and the heat transfer through the multi-layer construction can be determined as a function of the irradiation parameters.  
the experiments performed in the course of the project showed that using specific textiles with adequate coatings, passive systems can be manufactured which provide sufficient protection against incident laser radiation with an average power density of up to 900 kw/m2 for at least four seconds. this exceeds the protective ability, provided by systems actually available on the market, by about one order of magnitude. in general, the protective ability increases with the mass per unit area of the textile layers used, however this is in contrast to the ergonomic requirements of the protective clothing. here, a compromise has to be found between the protection level and the wearing comfort. regarding the developments done so far, the mass per unit area is still up to 1,000 g/m2. in terms of ergonomic aspects, a mass per unit area of less than 600 g/m2 is desirable according to the project partners' experience.  
however, it is noticed that single-layer systems with a mass per area e.g. of about 300 g/m2 provide a protection level of 120 kw/m2. by adding an adequate coating, the protection level can be increased by a factor of about 2.5.  
  
regarding active laser ppe systems, it could be shown that upon laser irradiation of sufficiently high-power density, adequate designs of the sensors described above are able to generate signals suitable to achieve a shutdown of the laser system within less than 100 ms, using the wireless connection. based on these results, laser-protective clothing can be manufactured ensuring protection against laser power densities of up to more than 20 mw/m2 by fast laser deactivation. this means that the pure passive protection level explained above is further exceeded by a factor of 25. during the irradiation time, a sufficiently high passive protection has to be guaranteed, i.e. the 2nd degree burn threshold must not be exceeded. theoretically, this combined passive protection may be less than the protection of pure passive systems, because the reaction time of the active systems is much smaller than the native reaction time of the ppe user. in case the laser can be activated without coupling to the active laser ppe or curtain by non-authorised bridging of the safety control, it is helpful to have a high passive protection level in order to tackle potential misusage of the laser ppe.  
  
3.4. prototypes of passive and active laser ppe and curtains  
corresponding to the large number of possible applications and to the resulting manifold requirements with respect to laser ppe and curtains, several ppe and curtain variants have been realised and different textile-layer combinations and multi-layer thicknesses have been implemented up to the project end in order to be able to choose adequate ppe and curtains for the relevant laser sources with their different powers and for the resulting fel values.  
first, several design studies were performed. as examples, figure 8 shows design solutions for passive and active jackets and trousers.  
  
after intensive discussions between designers, ppe manufacturers, and end-users, the following prototypes were manufactured in order to demonstrate the functionalities and the limits with respect to the practical handling. for each prototype, different design solutions were realised and tested. furthermore, additional applications such as pockets, air-ventilation, sleeve fasteners, etc. were investigated, thus always taking into account protection as well as comfort aspects.  
several passive laser ppe prototypes were manufactured. figure 9 shows some examples:  
â¢ passive aprons  
â¢ passive jacket  
â¢ passive gloves  
â¢ passive trousers  
  
the prototypes consist of single and multi-layer protective textiles. partly, uncoated materials were used as outer layer. in case of the gloves, a higher sensitivity and improved haptics can be reached in this way, providing a sufficiently high protection level in the area which cannot be irradiated. also for applications with lower laser powers, the coating can be omitted to achieve a higher comfort and breathabilitiy of the textile.  
   
for the demonstration of the functionality of the active laser-protective systems, several active ppe and curtain prototypes were manufactured using both active sensor types described in section 3.2. figure 10 shows some examples:  
â¢ active curtains  
â¢ active aprons  
â¢ active jacket  
â¢ active gloves  
  
in all cases, the active prototypes consist of a textile multi-layer system with the sensor elements embedded. the coating of the outer layer is rather important to reduce the energy input into the material as much as possible. the gloves prototype shown in figure 10 also contains uncoated material in the inner hand in order to provide improved haptics. this design should only be used in case of impossible irradiation of this area.  
  
in order to provide the user of the laser-protective clothing with a high degree of ergonomics and wearing comfort, practical tests were performed with the prototypes developed and manufactured in the course of selected industrial applications of hand-held laser processing devices and portal systems. based on the results obtained, the protective systems were optimised with respect to their functional design.  
  
for the exemplary application of a hand-held material processing using a high-power laser system with an emitted power of up to 5 kw as well as for laser cleaning applications, field tests have been performed using the protective clothing and curtain prototypes that have been manufactured in the course of the project. figure 11 shows exemplary scenarios during which the wearing properties of the ppe in terms of jacket, gloves, apron, and trousers have been evaluated.  
  
apart from laser ppe, active laser-protective curtains have been manufactured and equipped with the same wireless communication unit as the active laser ppe. in the field of laser ppe, it has to be verified depending on the realised variant which active sensor is most suitable. for the realisation as laser-protective curtain, both sensor types presented in this report may be used in principle and have already been tested successfully.  
  
a major objective of future development work will be the reduction of the mass per area of the multi-layer systems to improve the everyday suitability of the protective clothing. for this purpose, feedback of industrial users with respect to ergonomics and comfort, experienced during practical tests, shall be taken into account.  
  
3.5. detailed description of testing methods  
in the following, the most relevant testing methods used for the qualification of textile-based laser ppe and curtain system are described. this will be the basis for the initiation of a testing standard.  
the experimental investigations are divided into low-signal measurements, which do not damage the material or change the optical or thermophysical properties, and high-power tests, which are destructive due to the high laser powers used, in order to show the material behaviour under realistic conditions and including time-dependent changes.  
  
3.5.1. optical qualification  
in order to gather basic information about the optical properties of protective systems with respect to laser radiation of different wavelengths, the protective systems can be investigated by low-signal test methods in a first step. commercial spectrometers and specific mathematical models to calculate the important criteria can be used to determine the low-level transmittance and reflectance of the protective systems.  
taking into account the dependence on the irradiation time, values for the maximum permissible exposure of the skin regarding direct laser irradiation (mpeskin) according to din en 60825-1:2001 are shown in figure 12 for different laser wavelengths (near infrared lasers, co2 lasers). below these exposure limits, no damage is expected, and hence neither protective clothing nor gloves are required.  
  
part of the project work was the definition of a testing procedure, regarding among others the optical properties, which shall serve as basis for the testing standard. relevant testing methods for the optical qualification of protective systems against laser radiation, made from technical textiles and natural fabrics, are:   
â¢ classic rta (reflectance, transmittance, absorbance) measurements   
to determine spectrometric information  
â¢ brdf and btdf (bidirectional reflectance/transmittance distribution functions) measurements for single wavelengths with higher power limit compared to rta measurements  
â¢ comparison of transmittance values with mpeskin  
  
reflectance, transmittance, and absorbance (rta) are the most important evaluation criteria for the low-signal measuring setup. if the protective system shows high transmittance values because of its optical properties, mpeskin can be exceeded easily for relatively low laser powers. this may cause thermal damages of the skin (second degree burn) even within the reflex time, i.e. before or while the affected body part is drawn back. the foreseeable exposure limits (fels) have to be assessed at the outside of the protective system. dependent on the spectral transmittance of the textile system, it can be determined whether mpeskin is exceeded at the bottom side or if it is generally possible to avoid skin damages within the reflex time.  
  
3.5.1.1. spectrometer with integrator unit (rta test method)  
in the course of the project, a customary spectrometer (perkinelmer lambda 900, figure 13) was used to determine the general optical properties of the textile fabrics.   
generally, this instrument provides a wavelength range from 280 to 2500 nm. this range includes the emission wavelengths o ...

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the major project objectives were:  
â¢ to open new markets for high-performance laser-protective clothing and curtains as well as for the testing procedure, especially encouraging participating smes to widen their product range and to directly benefit from the project developments and prototypes,   
â¢ to sustain the growth of laser technology by providing means for the safe use of innovative technological developments such as hand-held laser devices for material processing and high power lasers with high brightness, to minimise health risks for the operators of hlds and automated laser machines, and consequently to reduce the number of related accidents,   
â¢ to contribute to the standardisation process considering laser-protective clothing and the corresponding testing procedures.  
  
the approach to achieve these objectives was to combine innovative laser technology with high performance textile technology. key developments were:  
â¢ passive functional multi-layer technical textiles, providing a high level of passive laser resistance,   
â¢ active functional multi-layer textiles incorporating sensors that detect laser exposure and are, by means of a safety control, able to deactivate the laser beam automatically,   
â¢ test methods and testing setups to qualify passive and active functional technical textiles and tailored laser-protective clothing, respectively.  
  
for the planned work, a consortium of 13 european partners, 9 of them being smes and 3 of them being research institutions, was founded, representing a goal-oriented combination of the competencies and skills required for a successful project progress and at the same time showing the great relevance of the topic for the sme sector.  
  
based on the textile systems developed, prototypes for passive and active gloves, jackets and aprons, as well as for active curtains were manufactured, the active systems connected to adequate electronics. in this context, properties such as wear resistance, inflammability and washability, as well as haptics and ergonomic aspects were taken into account. in addition, a specific testing rig was developed, incorporating instrumentation for the automated measurement of optical and thermophysical properties upon defined laser irradiation, in order to evaluate the laser-protective performance of the new passive and active textile systems. the results of these developments have been used to initiate the standardisation of the laser-protective textile testing procedure, which will later be the basis for the standardisation of the laser-protective clothing and curtains in terms of amendments of existing european standards or of completely new standards.  
  
for the exploitation of the project developments, 14 exploitable results have been defined, for which the partners will conclude contracts in order to achieve a close and successful cooperation after the project end. the market launch of the new passive and active laser-protective clothing and of the active curtains is expected within 2013.  
  
project context and objectives:  
2. project context and objectives  
2.1. technical background considering laser material processing  
lasers for material processing are mainly used as part of automated production systems. these laser machines are often closed (class 1 according to en 60825-1:2007 [1]), however, a class 4 laser is in operation inside the machine. under standard working conditions, these class 1 systems are safe due to housing and safety interlock circuits that switch off the laser source automatically upon opening the housing. in case of maintenance, service personnel may work under class 4 conditions. therefore, the safety interlocks have to be bridged. here, a notable risk of injury by accidental laser irradiation exists. the radiation is able to damage human tissues seriously, depending on the power density on the irradiated surface. this is not only relevant for the protection of the human eyes, for which adequate personal protective equipment (ppe) exists on the market in terms of laser goggles to be able to meet the maximum permissible exposure for the eye (mpeeye), but also for the protection of the human skin, for which the maximum permissible exposure (mpeskin) can be found in [1,2] as well, however almost no adequate ppe is available.  
hand-held laser processing devices (hlds) represent a niche application in the field of industrial laser material processing. such hand-held systems provide a high degree of freedom and thus a significantly higher potential risk considering the exposition to laser radiation. this means that the hld operator often works under class 4 conditions. in contrast to the typical usage of automated systems, the laser system user is specifically trained and knows about the potential risks of laser radiation. safety shielding and sensors reduce the risk of injury to a minimum. however, the risk of irradiating the skin either by the direct beam (binocular working station) or the reflected beam remains. such risks occur as well if persons have to work close to automated âconventionalâ laser processes which are not housed due to different reasons.  
there are two approaches to protect the human skin against the physiological effects of laser irradiation, which are both considered in the following:   
â¢ passive protection by means of materials or material combinations   
that provide a high level of passive laser resistance   
â¢ active protection by means of materials incorporating sensors   
that detect laser exposure and are, by means of a safety control,   
able to deactivate the laser beam automatically   
  
2.2. normative background considering laser-protective clothing  
to protect humans against accidental laser irradiation, comprehensive regulations and standards exist. based on the european standard en 60825-1 and on the eu directive 2006/25/ec [1,2], power density thresholds were defined to allow the allocation of laser systems to different classes as a function of the foreseeable exposure (foreseeable exposure limits â fels), and to ensure protection of the human eye and skin by taking technical, organisational or personal measures (maximum permissible exposures â mpeeye and mpeskin values). considering the protection of the operators' eyes against incident laser radiation, suitable eyewear of different producers exists with protection levels adapted to specific wavelength ranges and power density levels. the usage of such laser goggles is a standard procedure in industry, but also in scientific institutions dealing with laser radiation. this situation is completely different as far as the protection of the human skin is considered. only a few more or less common recommendations can be found regarding the type of clothing to be worn, e.g. concerning low flammability (see din en iso 11611 [3] and din en iso 11612 [4]). however, rules or standards which define the requirements concerning laser-protective clothing (laser ppe, in the following ppe referred to without equipment for eye protection) as well as standardised measurement methods and testing procedures suitable to reproducibly assess laser ppe do not exist. whenever laser ppe is needed, protective clothing originally produced for other industrial sectors is used, e.g. clothing for welders. there is almost no certified laser ppe available on the market, although the consequences of skin injuries caused by intenâ¬sive laser radiation are definitely serious: laser radiation emitted in the near-infrared (nir) range has a rather large depth of penetration into the human tissue and is mainly absorbed in deeper regions at blood vessels or bones. due to the heat released during the laser-tissue interaction, organic material below the upper skin layers is damaged or even evaporated to a notable extent, what may result in rather serious, painful, and interminable injuries [1,5,6,7,8].  
  
2.3. accidental background considering laser injuries  
regarding the turnover of about 7.2 billion euros (in 2011) for laser sources and laser processing machines worldwide in the field of industrial material processing, the high relevance of laser technology for the whole field of material processing is obvious. taking into account the whole machine tool market, the worldwide turnover amounted to about 62 billion euros in 2011. thus, the market for laser material processing is about one eighth of the machine tool market, what is a remarkable value. one of the global market leaders for lasers and laser systems is trumpf gmbh + co. kg, notable competitors are e.g. coherent, inc., rofin-sinar laser gmbh, ipg laser gmbh, newport corporation, and laserline gmbh.  
for conventional non-laser applications which are more or less dangerous, diverse regulations and standards for the testing and selection of proper ppe already exist since a long time, what is enforcing the prevention of accidents. consequently, the number of accidents with serious injuries is reduced by the usage of adequate ppe.  
as already described, such regulations only do not exist considering the protection of the human skin.  
a main problem regarding the argumentation for laser ppe is that the number of laser accidents concerning the workers' skin cannot be specified exactly. such accidents are often classified as e.g. conventional burnings or accidents caused by faulty machine controls, i.e. they are not allocated to the category of laser accidents at all.  
recent information of the german employers' liability insurance association [9] indicates a number of about 15 laser accidents in germany during 6% of the yearly working days. this number includes injuries not only of the skin, but also of the eyes. the extrapolation to one working year yields a number of 250 accidents. however, only notifiable accidents characterised by at least three days of absenteeism from work, are recorded. the number of unreported cases, i.e. of accidents with less severe injuries and of near-accident cases, is probably much larger. therefore, the above information of the german employers' liability insurance association can only lead to a very rough estimation of the real number of laser accidents concerning the workers' skin.  
nevertheless, it is assumed for this estimation that one tenth of the total number of recorded laser accidents concerns skin injuries. furthermore, it is assumed that 75% of all laser accidents are allocated to other categories of accidents, e.g. conventional burnings, accidents by faulty machine controls, etc. dividing by 10 and multiplying by 4 yields a number of about 100 laser accidents of the skin in germany per year. assuming that only 10% of all cases are reported, the number of risk situations would amount to about 1,000 cases per year. this is a really remarkable value, particularly as only the german industry is regarded. based on a rough research, there are up to 1,000 laser job-shops and comparable companies using laser systems for material processing in germany. this means that on average, one laser accident concerning the skin will happen per year in each laser company in germany with high probability.  
  
apart from the laser wavelength, the hazardous potential of hand-held laser devices or automated non-closed laser machines is strongly dependent on the distance of the potentially irradiated part of the human skin to the processing zone. the reason is that the intensity of focused laser radiation increases with the square of the decreasing distance to the processing zone. a typical situation which occurs to the operators standing next to the processing zone during hld use, and the corresponding distances from the processing zone to the different parts of the human body are shown in figure 1. according to this illustration, the most endangered body parts are the hands that operate the hld.  
  
in principle, three types of laser irradiation can be distinguished: irradiation by a diffusely reflected beam, irradiation by a directly reflected beam, and direct irradiation. according to this listing, the safety level required with respect to skin protection increases form left to right in figure 2.  
with respect to the dimensioning of laser ppe and curtains, the worst case has to be taken into account. mostly, hlds are equipped with safety systems, e.g. two-hand control buttons or contact pins, which should avoid direct irradiation by a focused laser beam.  
  
2.4. main project objectives  
the situation described above was the motivation for the work presented in this report. consequently, the main objective of the prosys-laser project was to combine innovative laser techâ¬nology with high performance textile technology in order to develop adequate passive and active protective clothing for the protection of the human skin against accidental laser irradiation and of adequate active protective curtains. here, the passive systems consist of functional multi-layer technical textiles, providing a high level of passive laser resistance. in addition, the active functional multi-layer textiles incorporate sensors that detect laser exposure and are, by means of a safety control, able to deactivate the laser beam automatically.  
due to the lack of regulations for testing and qualifying laser-protective textiles used as laser ppe, test methods were defined and validated. additionally, corresponding testing set-ups were developed.  
finally, the gap with respect to standardisation was bridged by the definition of a test procedure and the requirements with respect to laser ppe.  
the project developments were demonstrated by a set of tailored functional passive and active laser-protective clothing prototypes (gloves, jackets, aprons, trousers) and active curtains as well as by a prototype testing rig, providing the possibility to perform the specified low-power and high-power textile test procedure.  
  
project results:  
3. main project results  
3.1. passive laser-protective systems  
passive laser ppe serves as a kind of screen in order to protect the worker's skin directly under the clothing against incident laser radiation for as long as possible. however, the user of the laser-protective clothing must be enabled to remove the irradiated body part from the hazard area before a second degree burn occurs. therefore, the person concerned must be able to percept the effect of the laser radiation, i.e. the pain caused.  
stoll and chianta developed mathematical models for the onset of a 2nd degree burn (blister formation) by applying a 95% statistical probability. these models can be used flexibly for different energy types (flame, heat radiation, heat conduction) interacting with the human skin. in figure 18, the onsets of pain (first stimulus) and of 2nd degree burn (blister formation) are illustrated as a function of the heat flux and the exposure time (tolerance time of the unprotected skin) [10,11], see section 3.5.2.  
in this illustration, the reaction time, i.e. the time available to remove the affected body part from the hazard area before a 2nd degree burn occurs, is the time span between the intersections of the calorimetric measuring curve, giving the energy density flowing to the irradiated surface, with the stoll/chianta pain threshold curve on the one hand and the 2nd degree burn curve on the other hand. the bigger this time span, the more time has the affected person to react to the exposure. this time span should not be smaller than four seconds according to [12].  
  
this consideration results in the definition of the first main evaluation criterion, the so-called stoll/chianta criterion, for the qualification and assessment of the protective functionality of textile single or multi-layer systems to be used as laser ppe or curtain. the second criterion is an almost negligible transmissibility with respect to the laser wavelength used for the investigation, i.e. the transmitted power has to be smaller than the mpeskin value according to [1].  
  
in order to achieve an optimal protective functionality, the textile systems developed consist of one or more functional layers. as example, a 3-layers system is shown schematically in figure 3. in this construction, the outer layer is intended to reflect the incident radiation as good as possible. this reflection should be diffusive in order to prevent additional hazards for persons who stay near the processing zone.  
  
the function of the middle layer is to dissipate the part of the energy, which is not reflected, but transmitted or absorbed, over a larger surface area. therefore, the material should have a high scattering ability with respect to the transmitted laser radiation, as well as a high heat conductivity parallel to the surface. simultaneously, the remaining radiation should be absorbed to a large degree in order to minimise the energy transfer to the inner textile layer, which is adjacent to the skin, and thus to meet the mpeskin value.  
  
finally, the inner layer is an additional barrier for the energy incorporated into the system. correspondingly, the heat conductivity should be low. however, it has to be ensured that a small part of the energy can reach the skin in order to cause pain perception and the following movement reaction.  
  
3.2. active laser-protective systems  
in addition to a basic passive protective functionality, active laser-protective systems feature a possibility to deactivate the laser emission immediately in case of accidental irradiation. for this purpose, sensors are integrated into the multi-layer construction, generating an adequate electrical or optical signal upon irradiation, which is processed by a connected control unit.  
  
in general, such sensors may be designed as single-layer or multi-layer sensors. a possible setup is shown schematically in figure 4. the signal generation can either be based on a reversible or an irreversible effect: an irreversible change is easier to detect, but the sensor has to be repaired or exchanged afterwards.  
in the course of the project, two types of sensor systems for active laser ppe as well as for active laser-protective curtains were developed. the functionality of both sensor types is based on irreversible changes of the electrical properties.  
the first sensor is based on a wire that changes its electrical properties in case of a damage of the sensor structure (see figure 5, left).  
the second sensor variant consists of a multi-layer structure with conductive layers on the outer surfaces. in case of an irradiation, an electrical conduction is generated due to the melting of the layers (see figure 5, right).  
these sensors are integrated in the multi-layer structure in such a way that they are protected against mechanical influences as well as against a premature activation by very low (quasi non-dangerous) incident laser powers. furthermore, the layers below the sensor layer have to provide the ppe user with sufficient protection during the time span between the detection of accidental irradiation and the shutdown of the laser system until a safe condition is reached.  
  
finally, this dimensioning of the âpassiveâ protection as part of the active system is decisive for the high protection level of the whole system, meeting the two above-mentioned main evaluation criteria. however, weight and thickness of the textile construction are of particular importance for the usage of laser ppe with respect to wearing comfort and ergonomics (see section 3.3).  
  
to ensure a high degree of movement freedom and comfort for the ppe user, the electrical connection to the laser source is realised as a wireless connection.  
therefore, the sensors embedded into the textile structure are connected to a sensor unit (emitter, figure 6, left) which is linked to the safety unit (receiver, figure 6, right) via bluetooth. the safety unit is hardwired to the interlock of the laser source. this system can be used for active laser ppe, but also for curtains. the principle described here has been tested successfully for different sensor variants and a large range of laser powers. figure 7 shows as a scheme of the intended use of such active laser ppe and curtains to protect the operator as well as the persons which also stay in the hazard area.  
  
in order to provide maximal system reliability, a high robustness of the wireless communication has to be ensured. the specifications of this system have been defined in terms of system architecture, sensor block diagrams, and safety units, as well as the definition of the safety protocol layer. software programming and adaptation with respect to the specific requirements of the active concept regarded have been performed. the system is configured in such a way that the safety control does not release the laser radiation unless a control signal is received from the sensor unit, confirming the proper sensor function. if the sensors are hit by laser radiation of a sufficiently high intensity, the electrical properties are changed significantly which is detected by the sending unit and submitted to the safety control. thus, the laser can be switched off or the radiation can be blocked immediately.  
  
3.3. evaluation and assessment of potential laser-protective systems  
two main criteria for the qualification of laser ppe were identified (see above): the mzbskin value and the so-called stoll/chianta criterion have to be met.  
as secondary evaluation criteria, the results of the visual observation and assessment of the samples upon laser irradiation can be considered, e.g. showing the changes of the material structure in terms of hole formation, shrinkage, etc. an afterburning time of more than 2 seconds is not allowed according to [13]. furthermore, the textile multi-layer systems should be washable or cleanable without suffering a significant change of the specific optical and thermophysical properties in order to be useable as protective clothing against laser radiation successfully. in addition, the textile material combination should have a sufficient high temperature resistance.  
for the systematic and reproducible qualification of the laser-relevant properties mentioned, a specific testing setup was designed, which combines several optical and thermal measurement methods (see section 3.8). in particular, diffusive and specular remittance and transmittance of the material combination considered may be investigated for the laser wavelength and the heat transfer through the multi-layer construction can be determined as a function of the irradiation parameters.  
the experiments performed in the course of the project showed that using specific textiles with adequate coatings, passive systems can be manufactured which provide sufficient protection against incident laser radiation with an average power density of up to 900 kw/m2 for at least four seconds. this exceeds the protective ability, provided by systems actually available on the market, by about one order of magnitude. in general, the protective ability increases with the mass per unit area of the textile layers used, however this is in contrast to the ergonomic requirements of the protective clothing. here, a compromise has to be found between the protection level and the wearing comfort. regarding the developments done so far, the mass per unit area is still up to 1,000 g/m2. in terms of ergonomic aspects, a mass per unit area of less than 600 g/m2 is desirable according to the project partners' experience.  
however, it is noticed that single-layer systems with a mass per area e.g. of about 300 g/m2 provide a protection level of 120 kw/m2. by adding an adequate coating, the protection level can be increased by a factor of about 2.5.  
  
regarding active laser ppe systems, it could be shown that upon laser irradiation of sufficiently high-power density, adequate designs of the sensors described above are able to generate signals suitable to achieve a shutdown of the laser system within less than 100 ms, using the wireless connection. based on these results, laser-protective clothing can be manufactured ensuring protection against laser power densities of up to more than 20 mw/m2 by fast laser deactivation. this means that the pure passive protection level explained above is further exceeded by a factor of 25. during the irradiation time, a sufficiently high passive protection has to be guaranteed, i.e. the 2nd degree burn threshold must not be exceeded. theoretically, this combined passive protection may be less than the protection of pure passive systems, because the reaction time of the active systems is much smaller than the native reaction time of the ppe user. in case the laser can be activated without coupling to the active laser ppe or curtain by non-authorised bridging of the safety control, it is helpful to have a high passive protection level in order to tackle potential misusage of the laser ppe.  
  
3.4. prototypes of passive and active laser ppe and curtains  
corresponding to the large number of possible applications and to the resulting manifold requirements with respect to laser ppe and curtains, several ppe and curtain variants have been realised and different textile-layer combinations and multi-layer thicknesses have been implemented up to the project end in order to be able to choose adequate ppe and curtains for the relevant laser sources with their different powers and for the resulting fel values.  
first, several design studies were performed. as examples, figure 8 shows design solutions for passive and active jackets and trousers.  
  
after intensive discussions between designers, ppe manufacturers, and end-users, the following prototypes were manufactured in order to demonstrate the functionalities and the limits with respect to the practical handling. for each prototype, different design solutions were realised and tested. furthermore, additional applications such as pockets, air-ventilation, sleeve fasteners, etc. were investigated, thus always taking into account protection as well as comfort aspects.  
several passive laser ppe prototypes were manufactured. figure 9 shows some examples:  
â¢ passive aprons  
â¢ passive jacket  
â¢ passive gloves  
â¢ passive trousers  
  
the prototypes consist of single and multi-layer protective textiles. partly, uncoated materials were used as outer layer. in case of the gloves, a higher sensitivity and improved haptics can be reached in this way, providing a sufficiently high protection level in the area which cannot be irradiated. also for applications with lower laser powers, the coating can be omitted to achieve a higher comfort and breathabilitiy of the textile.  
   
for the demonstration of the functionality of the active laser-protective systems, several active ppe and curtain prototypes were manufactured using both active sensor types described in section 3.2. figure 10 shows some examples:  
â¢ active curtains  
â¢ active aprons  
â¢ active jacket  
â¢ active gloves  
  
in all cases, the active prototypes consist of a textile multi-layer system with the sensor elements embedded. the coating of the outer layer is rather important to reduce the energy input into the material as much as possible. the gloves prototype shown in figure 10 also contains uncoated material in the inner hand in order to provide improved haptics. this design should only be used in case of impossible irradiation of this area.  
  
in order to provide the user of the laser-protective clothing with a high degree of ergonomics and wearing comfort, practical tests were performed with the prototypes developed and manufactured in the course of selected industrial applications of hand-held laser processing devices and portal systems. based on the results obtained, the protective systems were optimised with respect to their functional design.  
  
for the exemplary application of a hand-held material processing using a high-power laser system with an emitted power of up to 5 kw as well as for laser cleaning applications, field tests have been performed using the protective clothing and curtain prototypes that have been manufactured in the course of the project. figure 11 shows exemplary scenarios during which the wearing properties of the ppe in terms of jacket, gloves, apron, and trousers have been evaluated.  
  
apart from laser ppe, active laser-protective curtains have been manufactured and equipped with the same wireless communication unit as the active laser ppe. in the field of laser ppe, it has to be verified depending on the realised variant which active sensor is most suitable. for the realisation as laser-protective curtain, both sensor types presented in this report may be used in principle and have already been tested successfully.  
  
a major objective of future development work will be the reduction of the mass per area of the multi-layer systems to improve the everyday suitability of the protective clothing. for this purpose, feedback of industrial users with respect to ergonomics and comfort, experienced during practical tests, shall be taken into account.  
  
3.5. detailed description of testing methods  
in the following, the most relevant testing methods used for the qualification of textile-based laser ppe and curtain system are described. this will be the basis for the initiation of a testing standard.  
the experimental investigations are divided into low-signal measurements, which do not damage the material or change the optical or thermophysical properties, and high-power tests, which are destructive due to the high laser powers used, in order to show the material behaviour under realistic conditions and including time-dependent changes.  
  
3.5.1. optical qualification  
in order to gather basic information about the optical properties of protective systems with respect to laser radiation of different wavelengths, the protective systems can be investigated by low-signal test methods in a first step. commercial spectrometers and specific mathematical models to calculate the important criteria can be used to determine the low-level transmittance and reflectance of the protective systems.  
taking into account the dependence on the irradiation time, values for the maximum permissible exposure of the skin regarding direct laser irradiation (mpeskin) according to din en 60825-1:2001 are shown in figure 12 for different laser wavelengths (near infrared lasers, co2 lasers). below these exposure limits, no damage is expected, and hence neither protective clothing nor gloves are required.  
  
part of the project work was the definition of a testing procedure, regarding among others the optical properties, which shall serve as basis for the testing standard. relevant testing methods for the optical qualification of protective systems against laser radiation, made from technical textiles and natural fabrics, are:   
â¢ classic rta (reflectance, transmittance, absorbance) measurements   
to determine spectrometric information  
â¢ brdf and btdf (bidirectional reflectance/transmittance distribution functions) measurements for single wavelengths with higher power limit compared to rta measurements  
â¢ comparison of transmittance values with mpeskin  
  
reflectance, transmittance, and absorbance (rta) are the most important evaluation criteria for the low-signal measuring setup. if the protective system shows high transmittance values because of its optical properties, mpeskin can be exceeded easily for relatively low laser powers. this may cause thermal damages of the skin (second degree burn) even within the reflex time, i.e. before or while the affected body part is drawn back. the foreseeable exposure limits (fels) have to be assessed at the outside of the protective system. dependent on the spectral transmittance of the textile system, it can be determined whether mpeskin is exceeded at the bottom side or if it is generally possible to avoid skin damages within the reflex time.  
  
3.5.1.1. spectrometer with integrator unit (rta test method)  
in the course of the project, a customary spectrometer (perkinelmer lambda 900, figure 13) was used to determine the general optical properties of the textile fabrics.   
generally, this instrument provides a wavelength range from 280 to 2500 nm. this range includes the emission wavelengths o ...

# COTTONBLEACH

Project Acronym: COTTONBLEACH

programme & topic: FP7-SME SME-2

Most frequent returning words in objectives:

* ('bleaching', 49)
* ('peroxide', 46)
* ('hydrogen', 36)
* ('cotton', 32)
* ('production', 27)
* ('process', 25)
* ('cottonbleach', 19)
* ('project', 19)
* ('textile', 18)
* ('water', 17)
* ('whiteness', 17)
* ('pre-treatment', 15)
* ('enzyme', 15)
* ('degrees', 15)
* ('celsius', 15)
* ('cost', 14)
* ('results', 14)
* ('laccase', 14)
* ('temperature', 14)
* ('conditions', 12)
* ('consortium', 11)
* ('costs', 11)
* ('acid', 11)
* ('industry', 10)

executive summary:   
  
 the european union (eu) textile industry, worth over eur 119 billion and giving work to more than 1 million people, is a sector in which small and medium-sized enterprise (sme)s employ 70 % of the workforce in regions where textile plays a vital socioeconomic role. the overall competitiveness of this sector is straining under price competition from outside the eu, especially from the far east. in addition, european cotton manufacturers are facing a serious competitive threat as cotton loses ground to synthetics on the basis of price, perceived quality and diversity of end-uses.   
  
 global market pressures are compounded by the heavily chemical-dependant nature of the sector, subject to the cost of applying eu environmental legislation. current bleaching methods use hydrogen peroxide and in much lesser degree, sodium hypochlorite, resulting in fabric damage, formation of toxic by-products and large amounts of water and energy to remove these chemicals.   
  
 cottonbleach was born as a new solution for this problem that should improve textile quality while also promotes savings of energy and chemicals by means of the implementation of an innovative and more efficient bleaching process formed by a conjunction of two sequential enzymatic treatments enhanced through the use of ultrasonic techniques that promotes generation of powerful shock waves that cause effective stirring / mixing in the liquid-solid interface, improving homogenisation, solubilisation, mass transport and mass transfer phenomena. the implementation of cottonbleach technology within the conventional process has proved to be capable to provide higher whiteness levels even with lower temperatures and a decrease in chemicals consumption, which provides the basis to reach significant savings in textile industry.   
  
 the whole cottonbleach treatment involves a first enzymatic pre-treatment with laccases, enhanced with ultrasonic devices performance, a second enzymatic step with oxi-mtcdh (an enzyme developed by one member of cottonbleach consortium within the project's life) that results in in-situ hydrogen peroxide production when the optimal conditions for the enzyme are used, and a final bleaching step at lower temperatures improved by ultrasounds energy.   
  
 during the 36 months life of cottonbleach project, the consortium has not only carried out numerous laboratory tests, but also has designed, constructed and validated a final industrial cottonbleach prototype, based on a current machine design which has undergone significant updates to allow implementing the crucial ultrasonic devices. the machine has allowed the consortium to carry out several tests during the lasts months in order to verify the first laboratory results and definitely prove the accomplishment of the technical and scientific objectives.   
  
 the cottonbleach consortium comprises research and technological development (rtd) performers with strong expertise in process ultrasound enhancement and characterisation and development of enzymes, which have been supported by smes with expertise in enzyme production and in ultrasound technology. in addition, the consortium has counted also with an sme specialised in textile machinery manufacture, a cotton textile manufacturer / processor end-user and a spanish textile association, which have conferred the group with the essential know-how and experience to be successful in all its tasks.   
  
 project context and objectives:   
  
 the current global economic and financial crisis has severely impacted the textile and clothing industry - predominantly sme-based, with 73 % of the total labour force working in smes - with orders and production falling by double digits since october 2008. at the same time this sector is one of the hardest hit by other countries sheltering their local industry from competition.   
  
 the sector is still reeling from previous blows: the 2005 abolition of eu textile quotas which has opened the eur 66 billion value-added european textile market to low-cost asian producers, and the costs of complying with recently implemented environmental legislation (ippc and reach), has an estimated cost of eur 3.9 billion for the textile industry. in june 2008, the european council adopted a new reformed eu cotton support scheme, establishing national programs to facilitate cotton industry restructuring in light of the increasing loss of jobs and productivity. in 2007 alone, employment in the sector dropped by 6.4 % or nearly 165 000 employees compared to 2006 for the 27 member states, one of the highest losses in the last decade.   
  
 consequently, the sector is being forced to minimise operation costs and production losses. the proposed cottonbleach technology was thought as a technological tool to achieve these objectives by reducing fiber damage as well as chemicals and energy consumption, providing a cost effective process to comply with current eu environmental legislation instead of moving cotton finishing jobs to other countries with less strict environmental norms. the sme-ags behind the project illustrate the need with real examples from their members; company after company moving their bleaching operations to india and china for lack of competitive options in the eu from textile processing companies in compliance with eu environmental standards. even then, many are uncomfortable with the high health impact of the asian model and would much prefer to use bleaching technologies with minimal environmental impact. the 'green' nature of cottonbleach ensures that the benefits of this technology will remain in europe, as asian textile processors have no environmental concerns to motivate the adoption of green technologies.   
  
 regarding these chemicals used in the abovementioned treatments, the most common bleaching agents employed by the industry are based on sodium hypochlorite (for a limited set of applications) and hydrogen peroxide. nevertheless, for environmental reasons (possible formation of halogenated organic compounds) the use of chlorine-based components is now limited in europe to just a few particular cases, associated with knitted fabric and, in some cases, bleaching of yarn when a high degree of whiteness is required. consequently, h2o2 has gained popularity as a bleaching agent as it is non-yellowing, non-toxic (degradable into water and oxygen), and odourless. in addition, h2o2 does not have the effluent problem that is associated with chlorine bleaching regarding the formation of halogenated compounds. however, such bleaching solutions usually require 40-50 minutes and temperatures of 90 - 100 degrees celsius to obtain acceptable whiteness values added to the fact that simple solutions of h2o2 are ineffective in bleaching without additives.   
  
 main limitations of existing technologies include:   
  
 - chlorine-based bleaching can cause environmental problems due to the presence of chlorine breakdown products, leading to the formation of aox and other toxic compounds.   
 - naclo bleaching requires special safety measures, increasing the cost of the process.   
 - hydrogen peroxide bleaching methods require temperatures close to boiling point to obtain successful whiteness levels and therefore require high energy consumption.   
 - traces of hypochlorite and peroxide remain in cotton fabrics and can result in yellowing and damaging fibres, respectively, as well as interfere in dyeing and posterior cotton finishing processes. therefore, higher amounts of water and energy are needed to remove both from fabrics.   
 - extreme ph medium needed both in sodium hypochlorite and hydrogen peroxide bleaching processes produce high environmentally hazardous waste liquors (high bod and cod levels), requiring expensive water treatments.   
  
 project objectives   
  
 as a result of the above issues, the rtds of the consortium came with an innovative treatment that, within a eu financed seventh framework programme (fp7) project, would end with a pre-competitive prototype that could be further developed that promoted, as the main objective, to obtain a better bleaching process, faster and more efficiently than current peroxide processes.   
  
 the general overview of full treatment is shown in the diagram below, which also proves how the additional steps are integrated into the conventional process ones.   
  
 the technological and scientific objectives are listed below:   
  
 - develop the pre-treatment based on the use of laccase enzymes, cutting the need for h2o2 by 50 % and for rinsing water by 40 %;   
 - high frequency ultrasound will be tested for first time in this kind of application. the results obtained will be compared with those at low frequencies, comparing the effects on higher radical formation;   
 - the suitability of pulsed-ultrasound will be tested in order to improve the cost-effectiveness of the system, identifying the proper pulse conditions to achieve a balance between the cost and the bleaching effect. enhance the bleaching process by ultrasound performance, investigating suitable frequencies (20-600 khz) and intensities in order to optimise cavitation on an industrial scale;   
 - develop and find the optimal condition to obtain in-situ h2o2 production by means of glucose oxidase (gox) which should cover peroxide demand (5.44 g h2o2 / kg cotton), generating gluconic acid as by-product and thus avoiding the use of chemical stabilisers;   
 - soften the operational conditions (ph 8-9; temp. 50 degrees celsius; duration 30 min) reducing energy costs by up to 50 % and minimising fibre damage (also helped by the highly specific enzymes that will affect only non-cellulosic fibres, without damaging the cellulose part in cotton);   
 - validate with trials all these advantages scaled in a cost-effective pilot plant designed and constructed by the consortium, with optimal integration of the cottonbleach technology, to ensure the proposed 'add-on' system fulfils the objectives;   
 - obtain an 8% increase over current cotton fabric bleaching levels through classic methods;   
 - the proposed device, including equipment, installation and maintenance, might have a cost around eur 60 000.   
  
 project results:   
  
 project objectives were defined in the initial work programme of cottonbleach as work packages (wp)s and the main tasks were arranged according to the activity and their time requirements. this program might help manage the research and validation work by the partners to assure the fulfilment of the objectives during all project's duration. the sme partners and associations would be involved in the research field, supplying their specific knowledge and experienced know-how, although most part of the innovation must be carried out by the rtd performers.   
  
 - wp1 - system specifications   
  
 the first stage of the project was considered aiming to provide an overview of cotton manufacturing processes (paying special attention to the bleaching processes), acquire information from the end-users regarding industrials standards from health, safety and manufacturing point of view, legislation and requirements not covered by current technologies.   
  
 moreover, during the first technical meeting of the project, acatel (portuguese finishing textile company, mainly focused on dyeing, mercerising, bleaching, piece dyeing, printing, flocking and finishing of knitted fabrics in rope or garment) and brazzoli (italian worldwide leading manufacturer in the production of machines for dyeing and finishing of both woven and knitted textiles) shared with the consortium partners their case study with detailed information regarding the production processes that were being carried out in their facilities and technical information about textile machinery.   
  
 the studied bleaching processes were two: super white cotton and half bleaching (further dyed), since both cotton treatments represent a big part of their bleaching necessities.   
  
 wp2 - laccase pre-treatment enhanced with ultrasound   
  
 during wp2 the influence of laccase pre-treatment in the peroxide bleaching of cotton textiles was evaluated. with the aiming to reduce the amount of hydrogen peroxide consumption in bleaching process, the conditions of enzymatic pre-treatment were optimised for whiteness enhancement.   
  
 the first step was to introduce the laccase from ascomycete myceliophthora thermophila, which have proved ability to degrade and oxidise. various reaction factors were considered to optimise the enzyme pre-treatment for bleaching enhancement such as laccase dosage (0, 1, 4, 6, 10, and 20 u / ml), incubation temperature, and elimination of fabric preparation process. furthermore, the decrease of hydrogen peroxide consumption was attempted in bleaching process after enzyme pre-treatment. previously desized and desized / scoured cotton fabrics were incubated in 0.1 m acetate buffer, ph 5, in the presence and absence of laccase enzyme.   
  
 after termination of enzyme pretreatment, the fabrics were taken and washed off in warm water for 10 minutes to completely remove the residual enzymes from the surface of fabrics. all the processes of enzyme pre-treatment and bleaching process using hydrogen peroxide were carried out on desized and desized / scoured cotton fabrics.   
  
 for each process, the best conditions using ultrasound were set and compared with the results made in conventional equipment. different ultrasonic powers were studied (30, 60, 90, 120 w) at frequency: 850khz.   
  
 main results:   
  
 a. determination of the most promising source of laccase, namely ascomycete myceliophthora thermophile;   
 b. characterisation of the best processing parameters for enzymatic pre-treatment:   
 b1. the optimum temperature for ensymatic treatment resulted at 50 degrees of celsius, since the enzyme maintained stable for 1 hour of incubation and lost just 10 % of its activity after 24 h;   
 b2. the laccase concentration for pre-treatment was optimised (2 u / ml);   
 b3. the optimum time of incubation was â½ hour;   
 b4. washing for 10 min. at 50 degrees of celsius with lutensol at25 (1g/l);   
 b5. 50% of protein adsorption at the moment of pre-treatment on scoured fabrics;   
 b6. whiteness (w\*)= 35 for fabric samples given by acatel.   
  
 c. characterisation of the best process conditions of ultrasonic bleaching:   
 c1. for half-bleaching: 1g / l hydrogen peroxide; 1 g / l sodium hydroxide; 80 degrees of celsius for 120 min.; 10 min. of washing with tap water (w\* equal to 63.5);   
 c2. for super-white: 8g/l hydrogen peroxide; 4 g/l sodium hydroxide; 80 degrees of celsius for 1 hour.; 10 min of washing with tap water (w\*77.1).   
 d. determination of the synergistic effect provided by the ultrasounds surrounding the cotton fibres during the bleaching step.   
 wp3 - bleaching process characterisation   
  
 within the tasks carried out at wp3, cric (rtd) characterised the ultrasonic bleaching enhancement through experimentation at fisa's (sme) facilities, optimising bleaching process under cavitation. partner fisa is specialist in design, manufacture and sale of automated ultrasound cleaning machines, so they counts with testing laboratories for best cleaning conditions characterisation under ultrasonic fields, equipped with temperature controlled stainless steel vessels, which include piesoelectric and magnetoestrictive transducers.   
  
 the extensive experimentation allowed the rtd to identify the most optimal processing parameters to obtain the highest cotton's whiteness. the tested parameters were:   
  
 - ultrasounds (two kinds were tested: piesoelectric and magnetoestrictive);   
 - temperature (70, 90 degrees celsius);   
 hydrogen peroxide concentration (2, 4, 8 g / l);   
 - processing time (30, 60 min).   
  
 the final whiteness measurement for each sample that had undergone a different treatment involving a specific combination of parameters was evaluated through a spectrometer, which returns values of berger's index, providing reliable information about the cotton's whiteness level and allows doing comparisons between different values. the whiteness increases proportionally to the berger index.   
  
 main results   
  
 a. the calorimetric data allowed evaluating the ultrasonic bleaching enhancement through experimentation, confirming that applying ultrasounds while the bleaching process is being carried out has a positive effect in its efficiency. as it can be observed in the graph below, same raw cotton fabrics, having undergone the same bleaching process with identical operational parameters, resulted in higher whiteness when ultrasonic transducers were working in the vessels.   
 b. however, there were no significant differences between the results obtained with piesoelectric or magnetoestrictive devices, so it has been not possible to conclude that one kind provides higher whiteness levels than the other.   
 c. nevertheless, the results achieved by university of minho and cric during experimentation allowed identifying the piezoelectric technology as the best technique in terms of performance related to costs. taking into account also power density, and based on the experience cumulated by the experts participating into the project, the power scale-up for the devices was 1 kw.   
  
 in addition, further experimentation at fisa's facilities included also the enzymatic pre-treatment before bleaching step, consisting of a 30 minutes process at 50 degrees of celsius, with ultrasounds and laccasse concentration of 2 u / ml , since these were the optimal processing conditions, specified by tem as the conclusion of their laboratory tests. the experimentation within the following bleaching step also allowed obtaining some evidences about how the temperature, processing time and peroxide concentration affected on the final whiteness.   
  
 - comparing the values of wi berger of all the tests, the whiteness achieved after laccase pre-treatment was significantly higher the obtained under same conditions with conventional bleaching process. furthermore, it was proved that, even using lower peroxide concentrations, the wi berger at 90 degrees of celsius was higher than the maximum achieved during the conventional test.   
 - the laccase pre-treatment accelerates the bleaching speed, since higher whiteness values were obtained after 30' bleaching process with enzymatic pretreatment than with 60 min conventional process without the first enzymatic step.   
 - the temperature proved to be the most critical factor to improve the final whiteness. the targeted goal of decreasing the processing temperature till 70 degrees of celsius had to be reconsidered in future tests carried out in the final pilot plant, since it was not possible to conclude that combining temperature and peroxide reduction would not negatively impact on the whiteness.   
  
 wp4 - peroxide production from desizing waste water   
  
 gras university started performing its work being focused on investigating gox and its potential within hydrogen peroxide production.   
  
 nevertheless, during the project's life, a relatively new highly promising ensyme showed several advantages compared with gox. consequently, the interest of the project was modified and the researchers also focused their attention and put higher efforts to compare both and arise with the most promising and suitable hydrogen peroxide producer. advantages linked to cdh are:   
  
 (i) its massive production for industrial scale,   
 (ii) in-situ peroxide production (cdh binds to cotton, producing h2o2 onto the fibre) and,   
 (iii) being capable to use other monosaccharides as substrate (glucose, cellobiose, lactose, maltose).   
  
 considering these first findings, the following activities, aimed at defining the reaction conditions and treatments for in situ generation of hydrogen peroxide, were carried out during the course of the year:   
  
 0. studying the most suitable carbohydrate substrates;   
 1. production of recombinant myriococcum thermophilum mtcdh;   
 2. study h2o2 production using gox and cellobiose dehydrogenase (cdh);   
 3. peroxide production;   
 4. bleaching process using desizing waters.   
  
 a. studying the most suitable substrate   
  
 - gox requires only glucose as a substrate. however, cdh is able to use other several carbohydrates, especially disaccharides arising from the desizing and scouring processes.   
 - different concentrations of carbohydrate substrates (lactose, glucose, maltose, cellobiose) were incubated with cdh, and it was found that the highest concentrations of hydrogen peroxide were produced in the presence of lactose.   
  
 b. production of recombinant mtcdh   
  
 since the preliminary studies showed many advantages of using cdh instead of gox, an overnight pre-culture of the pichia pastoris strain pmts (carrying the mtcdh gene) was inoculated into 30 l of production stage medium in a 70-l bioreactor, and a total of 700 mg partially purified mtcdh was obtained, which has been used during the project. the final recombinant cdh preparation had a specific activity of 3.5 u mg-1.   
 in terms of cost, although not commercially available, cdh cost is estimated at around eur 30/kg lyophilised. however, we expect these costs will be more competitive.   
 nine amino acids near the active site were selected for mutation (c291x, n292x, w295x, l324x, t599x, r601x, s699x, n700x and n732x) and libraries with more than 400 clones each have been constructed.   
  
 c. optimising h2o2 production   
  
 this task was mainly focused on studying the variables that affects hydrogen peroxide production, doing a higher effort in demonstrating if the presence of gluconic acid, obtained as a b product during the enzymatic production of h2o2, could lead to enhanced stabilisation of hydrogen peroxide acting as the chelating agent substitute.   
  
 the activities carried out to characterise the stage of hydrogen peroxide production are:   
  
 a. effects of temperature on hydrogen peroxide in the presence of gluconic acid;   
 b. effect of metals present on the cotton on hydrogen peroxide (in the presence of gluconic acid);   
 c. comparing the stabilising effect of gluconic acid and dipicolinic acid.   
  
 - the effects of the temperature were studied by monitoring during 1 hour the stability of the hydrogen peroxide, while it was incubated in 1mm of gluconic acid. although there were no significant changes at 50 degrees celsius, the concentration of hydrogen peroxide at 90 degrees celsius showed a decomposition more pronounced, so unfortunately, the researchers must assume that, at standard bleaching temperatures, the gluconic acid cannot offer protection to hydrogen peroxide.   
 - hydrogen peroxide was incubated during 2 hours in the absence and presence of different metals (cooper, zinc, manganese, calcium) and the hydrogen peroxide concentration was monitored during this period. the amount of hydrogen produced in the absence of the metals was approximately 40 % higher than in the presence of metals.   
  
 the metals tends to react with the hydrogen peroxide generating peroxides in the process as well as reacting with acids producing salt and water, so the results of the studies showed how the hydrogen peroxide decreased in the presence of metals directly related to the increase in metal concentration. this effect came from both sides, the peroxide reacts with the metals and the reaction with gluconic acid also shifted the ph, resulting in the destabilisation of hydrogen peroxide.   
 - the stability of hydrogen peroxide is more pronounced in the presence of sodium silicate as than gluconic acid, but unfortunately, it is also affected by metals, so both gluconic acid and sodium silicate could not protect the hydrogen peroxide decomposition.   
  
 further results   
  
 researchers from university of gras kept working after the period involved in wp4 and developed a new enzyme called oxymt-cdh, which can be presented as one of the most important results of cottonbleach project, and presents a high specificity towards different source of monosaccharide's (100 times more affinity than initial gox), producing in-situ larger amounts of hydrogen peroxide.   
  
 the experimental tests done at cric's facilities (wp6 'industrial validation') were carried out entirely using this new enzyme.   
  
 wp5 - integration and prototype construction   
  
 wp5 involved all the work done by the consortium concerning cottonbleach's pilot plant design and construction. the overview of the main results achieved during the previous work allowed describing the best design for the pilot plant, including flow diagrams, cad files and operational conditions. in addition, the secondary services needed for proper operation were defined at this stage also, as well as the user-friendly software specifications and the essential safety measures.   
  
 the final prototype has been constructed, based on a brazzoli finishing machine with a 5 kg load (concretely innolab ht5) that had to be modified accordingly to cottonbleach innovations requirements, which were studied and defined after gathering all the information from previous work done, and involved the preparation tanks (laccase solution, cdh solution and bleaching agents), the ultrasonic devices, the side equipment and the control software.   
  
 a. ultrasounds integration   
  
 ultrasounds interact at two different levels, with concurrent effects. during pretreatment ultrasounds are supposed to boost diffusion rates, while at the bleaching step, are supposed to boost diffusion rates as well as generate radicals able to whitening cotton fibres. for this reason, two different technologies were installed within the equipment: high power and high frequency ultrasonic devices.   
  
 (i) high power ultrasounds (hpu)s: 42 piezoelectric transducers (22 khz) were placed at the main tank bottom, close to the inner basket, where the cotton goods lay. the 50 w transducers were joined by six flanges (3 at each side in parallel) and can be modulated up to 2.1 kw (6 x 7 x 50w).   
 (ii) high frequency ultrasound (hfu)s): 850 khs (@ 400 w) piezoelectric transducers were installed at the recirculation pipe, just before the jet.   
  
 b. preparation tanks   
  
 one tank involves the enzymatic pre-treatment preparation by preparing the laccase solution while the watered solution is heated-up at 50 degrees of celsius (maximum activity) before filling the housing with the suspension.   
  
 two additional tanks were considered for hydrogen peroxide production by means of enzymatic reactions. even though cdh demonstrated better production ratios and flexibility than gox did, it is in an early stage of development yet, so the prototype was designed to be able to prepare both enzymatic solutions, since gox has proved to be more robust and commercially available, therefore more competitive from an economic point of view. gox: the tank reproduces the optimum conditions of temperature, substrate concentration and enzyme concentration, while the system is continuously regenerated and the produced hydrogen peroxide pumped to the system when bleaching.   
  
 cdh: the tank prepares the solution (0.05 u / ml), condition temperature (30 degrees celsius) and desired substrate concentration (between 60 and 100 mg / ml). when the recipe is finished, the content (water + enzymes + substrate) is introduced at the reaction tank, since cdh must bind to cotton to be effective.   
  
 c. side equipment   
  
 the prototype as a whole comprises also:   
  
 - team generator;   
 - propane gas installation;   
 - ultrasonic generators;   
 - peristaltic pumps to introduce the concentrated solutions and chemicals;   
 - (laccase enzyme + lutensol if necessary, gox - cdh enzyme, substrate (glucose), bleaching agents).   
  
 c. control system   
  
 the elements controlled by this software are:   
  
 - brazzoli machine (reel, pumps, heat exchanger/s, sensors and actuators);   
 - steam boiler (burner, feed pump, sensors and actuators);   
 - side equipment (hpu, hfu, peristaltic pumps, sensors and actuators).   
  
 wp6 - industrial validation   
  
 the main goal of this last technical wp was to the study covered the three main innovations of the project, namely laccase pretreatment, ultrasounds enhancement and hydrogen peroxide production; and in depth detail, the parameters studied were water, energy and chemicals consumption, as well as time, temperature and cost.   
  
 potential impact:   
  
 the eu textile industry, worth over eur 119 billion and giving work to more than 1 million people, is a sector in which smes employ 70 % of the workforce in regions where textile plays a vital socioeconomic role. the overall competitiveness of this sector is straining under price competition from outside the eu, especially from the far east. in addition, european cotton manufacturers are facing a serious competitive threat as cotton loses ground to synthetics on the basis of price, perceived quality and diversity of end uses. in june 2008, the european council adopted the reformed eu cotton support scheme, establishing national restructuring programmes to facilitate cotton industry restructuring and to enhance quality and marketing of the cotton produced.   
  
 global market pressures are compounded by the heavily chemical-dependant nature of the sector, subject to the cost of applying eu environmental legislation. current bleaching methods use hydrogen peroxide (h2o2) and in much lesser degree, sodium hypochlorite (naclo, aka bleach), resulting in fabric damage, formation of toxic by-products and large amounts of water and energy to remove these chemicals.   
  
 cottonbleach technology will deliver end-user textile ag members with savings reaching 140 000 eur / year for productions of 1 500 tonnes / yr of fabric (eu average), counting the savings in water, energy and chemicals against the new costs of enzymes and ultrasound. the expected cottonbleach system tag price is of 40 000 eur for sme-ag associates, a 33 % discount over the full tag price of eur 60 000. the production cost will be of eur 28 000, besides an additional fee of eur 1 000 for the installation and the specification of the equipment. most end-users have a technical maintenance department making installation costs overheads for them. the costs include the direct and indirect expenses related to staff, investment in machines and manufacturing tools, marketing activities, overheads and other operational activities, representing the 40% of the production costs.   
  
 cottonbleach will have a clear economic impact on the production costs associated with water use with savings of eur 190 000 / year, given the high water demand of the industry. cottonbleach technology will also lower operational temperatures and process duration. reducing the operating temperature to 40-50 degrees celsius can cut costs by up to eur 120 000 / year. finally, dropping enzyme prices and the cost of ultrasound (eur 3 / m3 water) ensure the cost-effectiveness of the proposed technology, avoiding the use of h2o2 and stabilisers (eur 130 000 / annum) and minimising fiber production losses (4 % or eur 70 000 / annum).   
  
 dissemination activities   
  
 the consortium carried out plenty of dissemination activities that had been previously planned within the dissemination actions plan and also a significant amount of additional actions, which involved both publications and events (fairs, seminars, conferences). among all this activities, also social networking has been encouraged by the creation of twitter, facebook and linkedin accounts, related to the project.   
  
 exploitation   
  
 at the end of the project, the sme-ag / sme partners are still planning to follow the initial business plan, described in section b.3.2 of annex i of the grant agreement. the business plan and the strategies towards exploiting the results have been discussed reiteratively. the consortium has devised an overall plan for the exploitation of foreground, taking into account that the sme-ags own all foreground but lack the capacity to exploit it commercially by own efforts. therefore, they shall reach a commercial agreement with utc, fisa and bra, under the following terms:   
  
 sme-ags will grant a manufacturing and commercialisation license to utc, fisa and bra for the cottonbleach system. the three companies have reiterated their interest for becoming licensees of the system if real benefits are foreseen.   
  
 - in this case, utc, fisa and bra will pay royalties to the sme-ags in exchange of the licensing, concretely 5 % of the gross benefit earn selling the equipment. the royalties percentage will be finally settled when the exploitation takes place. considering that the target operational cost of eur 0.16 / kg cotton has not been yet achieved, the actual percentage of royalties cannot be accurately calculated. once limitations will be arranged, operational cost will allow the smes to calculate their gross prof ...

# MODSIMTEX

Project Acronym: MODSIMTEX

programme & topic: FP7-NMP NMP-2007-3.2-1

Most frequent returning words in objectives:

* ('yarn', 65)
* ('textile', 51)
* ('properties', 40)
* ('system', 36)
* ('parameters', 33)
* ('yarns', 30)
* ('project', 26)
* ('model', 26)
* ('simulation', 24)
* ('process', 24)
* ('models', 22)
* ('structures', 19)
* ('sintex', 19)
* ('product', 18)
* ('fabrics', 17)
* ('cotton', 17)
* ('developed', 16)
* ('development', 16)
* ('research', 15)
* ('journal', 15)
* ('machine', 13)
* ('strength', 13)
* ('production', 12)
* ('software', 12)

executive summary:  
introduction and general technical goals  
the textile industry faces important challenges regarding the production of new advanced textile products. it is not possible to define the characteristics and parameters of a given textile structure due to the difficulty of measuring them. this situation makes very difficult to configure the machines involved in the production of such textiles; the typical practices consists in manufacturing samples and through trial and error adjust the processing operations until the desired characteristics are achieved in the final product. with this procedure it's very expensive to match the designer's idea with the final product. the production setup takes a long amount of time and efforts and increases the cost of the final product. this is especially critical when a company is trying to develop new technical textiles. the vast majority of the existing systems capable to simulate textile products are limited to the visual representation, without any kind of mechanical or physical evaluation of the properties of the textile structures. of course, these tools don't take into account the configuration of the production machinery, so they aren't capable of help in the setup of production machinery. unlike these conventional design systems, the core of this project is to develop a virtual simulation system of the physical-mechanical properties of the textile structures oriented to the fast setup of the machines involved in the whole textile chain manufacturing process (yarns, woven fabrics, knit fabrics, needle-punch non-woven, hydro-tangled non-woven, and composite structures).  
  
  
modsimtex project partners  
  
the research intended for this project is being developed by 5 textile institutes/universities (intexter-upc, kemlg-upc, tu-lodz, tu-liberec, stfi and ditf-mr), members of autex and textranet. combining the knowledge of these organizations, the full spectrum of textile knowledge, and more specifically, the knowledge on the simulation of textile structures physical properties is covered by this project.  
  
each member in the consortium is contributing in the project with an indispensable expertise area: intexter-upc gives its proven experience in managing european projects and also its knowledge of textile image processing and spinning techniques, tu-lodz and tu-liberec give a high skill in mathematical models, simulation and a.i applied to textiles, and stfi is in the lead of the non-woven research area in europe. the software development is mainly executed by infotex, which sells its textile design software to all europe. the required online analysis and metrology is completely assured by the participation of bms bvba, the world leader in on-line textile monitoring and process control. ditf-mr collaborates in this project with its high expertise in innovation management and information technologies in order to continuously assess innovation level and therefore the success of the system to be developed.  
  
the critical mass at the industrial participation level is excellent since this project has gathered 2 of the most important european textile machinery constructors (tfa alfa s.r.o and santoni spa) and 3 of the major textile manufacturers in europe (heimbach gmbh & co. kg, gebr. raders ag and sintex, s.r.o.); the expertise of these 5 companies in the textile processes knowledge (manufacturing parameters, knowledge on the products, machinery) will be invaluable to develop the integration of the simulation software modsimtex in the textile machinery.  
  
  
project context and objectives:  
the textile industry faces important challenges regarding the design of multifunctional textile products, because of the enormous difficulty to relate the design/processing parameters of the component materials with the quality parameters of the resulting textile structure. it is often impossible to define the characteristics and attributes of a given textile structure due to the difficulty (and sometimes impossibility) of measuring these parameters (parameters like flexibility and compressibility of some kind of fabrics). new multifunctional textiles have to meet a long list of quality and usage requirements with their attributes.  
  
the vast majority of the currently available textile design software applications, that are capable to graphically represent textile structures, are limited to the visual representation, without any kind of mechanical or physical evaluation of the properties of the textile structures. since their only mission is to represent the visual image of the yarns/fabrics, these software tools do not take raw materials, types of structures or their influence over the physical properties of the final textile into account. none of these currently available applications is capable to simulate the physical-mechanical properties and behaviour of the textiles. hence these systems lack the ability to assist in the rapid manufacturing process configuration.  
to overcome the described functionality limits of the currently available textile design systems, the objective of this proposal is to develop a simulation system for the physical-mechanical properties of the textile structures that enables the rapid manufacturing process configuration. the system will support the product development and production for all products in textile value-added chain (yarns, woven fabrics, knitware, and needle-punch non-wovens). this virtual construction system will allow the performance prediction of multifunctional textiles before the starting to manufacture. production machine settings will be both computation input an output. this will thus reduce dramatically the effort to produce small production lots and the process setting-up times (small or large lots).  
the project has therefore the following main objectives:  
- development of the simulation model of the physical properties of the basic structural units that compose the multifunctional textile structures.  
- development of a finite elements simulation system to simulate the physical properties of the textile structures, based on the mathematical models developed for these textile structures.  
- development of an artificial-intelligence based simulation system for the physical properties of textile structures.  
- implementation of the 2 simulation models (finite elements and a.i.) in one single composed simulation system that will be the core of the modsimtex software package which is the final milestone of the project.  
- integration of the simulation system results into the manufacturing process through the adequate interfaces, to produce real multifunctional textiles using the parameters established during the design process with the simulation software modsimtex.  
  
project results:  
4.1.1. description of the main s&t results/foregrounds  
4.1.1.1. spinning group  
 workgroup objectives  
- to exactly define which were the parameters that the system needed as inputs, as well as the resulting properties.  
- this parameters and properties had to accomplish the objective of not adding complexity to the simulation system, and at the same time, be capable of exactly defining the yarn structure from the point of view of the system user (mainly sintex). the functional range of the simulation system was established.  
- establish the ai simulation system requirements in the spinning field, as needed for the correct integration of both systems. the exact functional parameters of the machinery to be used were also specified, in order to adapt the simulation and the a.i. system to the production spinning machines, which was the final objective of the project  
- to obtain an analytical and mathematical model that describes the physical behaviour of the yarn produced with the most important spinning processes: ring and oe-rotor. these parameters were obtained in the wp 1 and were the basis for the final model.  
- to develop yarn analytical and mathematical models to simulate the physical behaviour of the yarn structural units.  
- developing of yarn samples and analyse them, obtaining reliable methods in order to determine the physical properties to test the validity of the models developed.  
- experimental measurements were also carried out using standards and these new analysis methods.  
- the a.i. development partners were provided with the information needed for them to represent correctly the problem, helping them to select the righ method and tool to the project.  
- a table of relationships between the variables of the process were defined, focused in the integration of the cbr system, along with the rest of algorithms to estimate parameters of the spinning process.  
 scientific objectives  
the main scientific objective were the development of a software tool (integrated in the software platform of modsimtex) that provides a complete technical solution for the product development and production problems of the staple fibres spinning mills, estimating with reliability the complete list of process settings as well as the total relevant product properties, as requested for the user, for a wide range of yarns in terms of fineness and raw material, using the combination of existing techniques, models and algorithms as well as new ones developed explicitly inside the project.  
to achieve this global scientific objective, many partial and progressive objectives were defined; the most relevant were:  
- study of the different spinning processes used by sintex and spinning mills in general, identifying the key variables, (inputs and outputs) as well as the most appropriate method for calculating them, applying different techniques progressively, in order to reduce degrees of freedom, starting from the most reliable methods.  
- study of the state of the art in order to identify existing mathematical models able to be applied in any step of the process and adapt them to the problem, defining their validity range.  
- development of new mathematical models, when suitable for the estimation of variables not covered by existing models (for both estimation of product properties as well as the settings of the product process).  
- configuration of a.i. techniques (cbr and ann) in order to provide a robust answer to the variables that cannot be estimated in any other way or to increase the confidence degree of the estimations provided by some models.  
 integration within the modsimtex framework  
the final objective for integration in the spinning group was to provide to the modsimtex system the functionality described as the first scientific objective. the industrial partner now has an application that allows him to store all his products and processes information and lets him try to find new improved product properties or optimize specific processes in a web interface, by only providing the desired product properties.  
the final product obtained is the ditf retrieval system with the added functionality of modsimtex.  
two main integration concepts were implemented in the final software for sintex:  
- a general system (suitable for most spinning mills): ditf retrieval system with the functionality of modsimtex added  
- a sintex specific system: an application covering the key aspects from the yarn to the fabric. for this, the ditf equation solver was the choice, as it can be easily manteined and upgraded by the end-user  
spinning workgroup activities  
analysis of the industry partner's business processes  
sintex was the spinning industrial partner of the project. it is a small spinning and weaving mill, and sells both yarn and fabric, using also its own yarns for the weaving processes.  
their spinning plant is focused in the production of short-fiber yarns from flock of natural fibers, man-made fibers or blends.  
the machinery available in the spinning line of the company allows them to cover a wide range of raw materials and yarn counts, but always working with short-fiber:  
the company is only using one spinning technology: compact spinning (from rieter in their case). this technology, (based upon a modification in the spinning triangle of the conventional ring spinning machine) allows them to produce high quality yarns (as this technology reduces significantly hairiness and improves evenness and strength under certain production settings (1) (2)), covering final uses especially for sport and work protection textiles between others.  
their product development is simple in concept and based on the experience of their spinning experts.  
sintex has his own analysis laboratory, and is able to perform the most common analysis necessaries in the above steps regarding dynamometry and evenness; this point were taked into consideration when establishing data inputs and outputs as well as the possibilities of implementation of the modsimtex system for sintex.  
sintex provided intexter a list of the process settings and product parameters that they use during the product development stage; after that, there was a discussion about which of them should be considered as inputs, outputs or both. after this stage, intexter extended these tables with many parameters that usually are not considered by the sintex. these additional parameters were considered necessary for the implementation of different calculation methods or valuable information for sintex in the future.  
the process was divided into two phases: preparation (covering from bale to sliver) and spinning. although sintex only uses compact spinning, it was also included oe-rotor parameters for generalization issues.  
processes inputs and outputs: preparation phase  
the following tables include the parameters that were taken into account in the process, as inputs, outputs or for intermediate calculation. the tables were divided into:  
- raw material (bulk fiber) parameters  
- process machinery settings used from bale to sliver or roving  
- yarn parameters (common for compact and oe-rotor)  
- spinning machine (compact or oe-rotor)  
some intermediate materials properties (sliver and roving) are considered inside the processing machine.  
the number of passes through the draw frame were taken as a parameter belonging to the process itself (so not included in the following tables), that should be considered as both input and output, depending on the data required by sintex in a determinate test.  
state of the art  
here, we summarize our conclusions to the state of the art that was done at the very first beginning of the project, in addition to the conclusions of the initial document developed by ditf-mr 'artificial intelligence in spinning'â.  
- there was no software providing an integrated solution like modsimtex in the staple fibre spinning area (although there is for wool).  
- there were lots of mathematical models for cotton or blend with pes that estimates dynamometric and geometric properties of the yarn, and most of them were quite old though still valid in its operational range (raw material, yarn count, spinning process). intexter had also some publications in this field.  
- the operative range for parameter estimation (especially outside a.i.) of the existing models is usually narrow in terms of raw material properties, spinning technology and yarn count.  
- there were almost no specific publications for polypropylene yarn parameter estimation, because the trend was to solve this problem by using ann and other a.i. techniques, that were easily adapted from cotton (where the publications intended was ) to other staple fibres.  
- cbr uses in this field were found in only few publications. in the a.i. field ann seemed to be the preferred a.i. technique.  
- since 2004 the svm (support vector machines) techniques gained terrain in the field of spinning parameter estimation.  
there was found only one similar, although very limited, solution: a tool for worsted spinning mills: sirolan yarnspec; this tool was created in 1996 and developed inside an aciar founded project (3) involving asian, chinese and australian partners.  
applying a simpler, similar system in the wool industry supposed reductions of 10% ends-down, 5%-8% speed improvement and increase of a 10% in weaving efficiency ratio (4)  
the package is commercialized by the company csiro textile and fibre technology, including some physical analysis equipment required by the system.  
there were found also some references to laboratory software that estimates specific parameters or performs simulations of especifics aspects of the yarn, like (5), that simulates the appearance of yarns in 3d, but with a very low functional range.  
material research  
the sources used for the material research had been: compendex, web of science, world textiles, google scholar.  
although lots of articles were evaluated, here are summarized the most relevant under our point of view and for our application case:  
the work of majumdar and majumdar (6) compared the results of breaking elongation (for cotton too) estimated by three methods: mathematical model, statistics model and ann, concluding that the best accuracy was obtained by ann, followed by statistics methods, and that mathematical models are the less accurate system. this was useful when integrating composed results offered by our system, because it seemed to be also applicable to oe and other raw materials.  
regarding mathematical modelling of staple fibre yarn, the existing models were basically developed for cotton, polyester or blends, and focused in the estimation of physical properties, especially yarn strength and elongation; and many of this models were quite old (before 1990 most of them) but some of them (7) (8) were considered adequate to be used as estimation models for cotton in the generic spinning calculations and also to be used as an starting point to be transformed to other fibres treated in the project (pp and lyocell).  
looking for advances in ways of calculating critic physical properties of the spun yarns, the following ones were also been found of interest for us:  
aggarwal (9) (10) provides two models of special utility covering high twisting yarns of co and blends, they were used as a project starting point with raw materials; on the other hand, low twist yarns were modelled in the work of shao (11), who studied the yarn behaviour starting from fibre slippage effects (the technique with which we had more experience), although the work even considered effects of cyclic loading. ghosh (12) provided also a very general model that uses as inputs the characteristics of the bulk fibre, and suitable for all the spinning technologies in focus, with an acceptable accuracy degree inside its operating range, so it was also considered for the application case development. the first part of this article (13) justified the effect of the yarn geometry in its strength properties.  
the model of koo (14) was especially useful for the project because was able to also estimate the variance of the yarn strength, with the input of cv values of raw material. moreover the method is applicable to other raw materials than cotton.  
a key point when processing the sliver was the drafting system. there were many variables involved and was mandatory to find which were the influencing ones; some literature was found, and pillay (15) in a very old article from 1964 gave important data about this point, studying also tension in the twisting zone and cursors, but always analyzed the resulting yarn hairiness (which was also interesting for us). however no literature was found on pressure clips.  
the internal models (developed in intexter) that were considered dealed with strength and elongation estimation and the modelling of the cross-section geometry of ring spun and oe-rotor yarns, developed (before the project started) by kassem (16) (17) and tornero; these models were found convenient after comparison with other existings with the same aim, although some modifications were needed for adaption to new raw materials and/or spinning technologies, and they were of interest for further applications in the weaving area, so they were considered too.  
artificial intelligence for the application case  
cbr is used in very few cases, and the most significant publication was evaluated (already found in the preliminary study of the art carried out by ditf during the project)  
looking for works dealing with polypropylene yarns, we didn't found any publication (only for continuous filament, also called yarn so it was a bit confusing when performing the searches); but taking into account the nature of teh ann calculations, it was considered that cotton or pes publications were also successful for our case.  
for predicting yarn properties from fibre properties, ann were used in many publications; chattopadhyay (18) was interesting because analyzed the performance of the network used (for cotton, but was found suitable for other materials). igadwa (19) used an ann to predict yarn properties in a case that was found problematic for us; he reduced the input variables to 14 (we had 30 at the moment), so this article was taked into account to understand the selection criteria.  
elaboration of yarn samples  
samples needed to validate theoretical results were produced by sintex and intexter. sintex produced the ring spinning and compact yarn samples while intexter produced the oe-rotor and ring spinning yarns (see table 1).  
sintex produced 68 different yarns. studying the composition influence (lyocell, polypropylene and polyester), spinning process used (kompact or conventional), spindle speed, yarn count and twist coefficient.  
intexter produced 155 different yarn (126 were oe-rotor and 29 ringspun conventional).  
as it is posible to see at the table 1, for conventional yarn, sintex produced the different yarns modifying the yarn configuration structure (yarn count and twist) and intexter focused in the process settings (previous draft, olc type and roller pressure).  
producer raw material spinning system variables studied main variables obtained  
sintex lyocell kompact spinning - spindle speed  
- yarn count  
- twist coeficient - yarn count  
- twist  
- strenght  
- elongation  
- tenacity  
- yarn eveness  
- thin places  
- thick places  
- neps  
 ring spinning   
 polypropylene kompact spinning   
 ring spinning   
intexter ring spinning - twist coefficient  
- previous draft  
- olc type  
- roller pressure  
- spindle speed - yarn count  
- strenght  
- elongation  
- tenacity  
- yarn eveness  
- thin places  
- thick places  
- neps  
- hairiness  
 oe-rotor - yarn count  
- twist coef  
- rotor speed  
- disgregator speed  
- rotor type  
- disgregator type  
- nozzle type  
- torque-stop type  
 lyocell   
table 1 ' yarn samples developed  
the laboratory analysis of all the samples were carried out by both intexter and sintex, obtaining dynamometric and evenness results.  
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4.1.1.2. knitting group  
 part a  
the aim of the knitting group was to develop a simulation system for the physical-mechanical properties of the knitted textile structures that enables the rapid manufacturing process configuration. this virtual construction system allows the performance prediction of knitted fabrics before the starting to manufacture. the project has had therefore the following main objectives:  
- development of the simulation model of the physical properties of the knitted textile structures. mathematical models will be developed to simulate the behavior of the knitted fabrics.  
- development of a finite elements simulation system to simulate the physical properties of the knitted textile structures, based on the mathematical models developed for these structures. analytical and next discrete model of the product allowing for the use of fem in order to analyze the product behavior under service load and its response, i.e. displacement, strain and stress distribution.  
  
these knitted fabrics are the basic structure of manufactured products on circular weft knitting machine mec-mor: above types of fabrics were made of the following raw materials:  
- cotton yarn with linear mass: 15 tex, 20 tex, 25 tex.  
- pes yarn with linear mass: 300/f72 dtex, 220/f72 dtex, 167/f48 dtex  
- pa yarn with linear mass: 312/f272 dtex, 234/f204 dtex, 156/f146 dtex  
- pa textured with linear mass:  
- pp yarn with linear mass: 300/f252 dtex, 200/f168 dtex, 140/f144 dtex  
  
for each type of stich and yarn linear density, firm santoni made fabrics variants for three values of cf factors: maximum, minimum and average (60 variants).  
with this raw materials were also made single jersey knitted fabrics with elastomeric yarns. a total 95 variants of knitted fabrics were made.  
the experimental results were used to develop a mathematical analytical model and were the base data to the model of artificial intelligence ai. to develop a mathematical model predicting the structural and physical parameters, it is necessary to know the relationships between the parameters of the structure and physical properties of knitted fabrics.  
the results of measurements of number of courses and number of wales were presented based on the model doyle - munden. according to this model, number of loops on surface unit is inversely proportional to loop length square.  
the results of strength along courses and wales measurements were presented as a function, where calculated value of these parameters is directly proportional to the product of adequate density and the tensile strength of the yarn  
 in the case of the ball bursting it was adopted, that value of this parameter is directly proportional to the product of horizontal and vertical stitch density pk, pr and the tensile strength of the yarn  
for the mathematical description of measurement results of air permeability of knitted fabrics, equation has been adopted, in which the value of this parameter is inversely proportional to the quota of the flat projection of loop forming yarn in the loop surface  
all proposed equations are therefore a function of the length of yarn in the loop.  
the matrix of influence of yarn parameters, machine technical parameters and process parameters (machine setting) on the structural parameters and physical properties of knitted fabrics was developed and the productivity of circular weft knitting machine for the purpose of simulation system, based on artificial intelligence ai.  
an example of modeling results of knitted fabrics properties, setting up and productivity of circular wft knitting machine.  
  
the order operations of mathematical calculation of the analytical model is to determine values for particular structural and physical parameters, whose value is determined for the extreme values of the coefficient cf. developed model, for the first time, allows to simultaneously determine all of the knitwear structural and physical parameters, under one of the parameters, for which a knitted fabric is designed. at the same time the setting parameters of knitting machine are determined, that is, the length of yarn per one cylinder rotation, the input yarn tension, take down tension of knitwear and productivity of the machine in m / h, m2/hi kg / h. for the purpose of fast setting parameter of knitting process, the concept of the automatic settings was developed. this concept refers to the three control zones:  
1. the thread feeding zone' in this zone feeding device is fitted out. the length of thread segment unwinding from yarn packing and feeding to needles per one turn of cylinder. is regulated.  
2. knitting zone' here the sinking depth is regulated through the change of stitch cams setting in individual systems; this adjustment influences of the input tension of thread. the stitch cams setting has to be fitted to length yarn.  
3. knitwear take-down zone' here the force which knitwear is drawn aside from the knitting zone is regulated.  
the basis of regulation is known the length of yarn per one machine rotation, determined from a mathematical simulation model. automatically setting the length of the intended value feed thread on one cylinder rotation takes place in a sequential manner by small steps.  
automatic adjustment of crochet is done with a computer while controlling adjustable parameters and their comparison with set values.in the case fulfill the conditions of the regulation of yarn length feeding, that is, when i l-lmi <iâµl input tension is regulated to the reference fo and take down tension fa according to the previously described steps 2 i 3.  
 part b  
the objective of this project was to develop a simulation system for the physical-mechanical properties of the knitted textile structures that enables the rapid manufacturing process configuration. this virtual construction system allows the performance prediction of knitted fabrics before the starting to manufacture. the project has therefore the following main objectives:  
- development of the simulation model of the physical properties of the knitted textile structures. mathem ...

# NANOBOND

Project Acronym: NANOBOND

programme & topic: FP7-NMP NMP-2008-4.0-7

Most frequent returning words in objectives:

* ('technology', 36)
* ('surface', 35)
* ('textile', 35)
* ('textiles', 33)
* ('project', 32)
* ('development', 30)
* ('products', 27)
* ('polymers', 22)
* ('properties', 19)
* ('developed', 19)
* ('performance', 17)
* ('industry', 16)
* ('applications', 15)
* ('technologies', 15)
* ('surfaces', 14)
* ('polymer', 13)
* ('activity', 12)
* ('nanobond', 11)
* ('market', 11)
* ('chemical', 10)
* ('articles', 10)
* ('coatings', 10)
* ('processes', 10)
* ('materials', 9)

the idea of the nanobond project comprised the development of a system consisting of:   
 (i) the chemical activation of the fibre surface with a polymeric nano-coating for durable binding of functional molecules;   
 (ii) the effective incorporation of a selected functional finish for permanent modification of the textile properties, in the first instance a non-leaching antimicrobial agent;   
 (iii) the development of a universal technology applicable at any type of textiles and non fibrous materials.   
  
 the practical starting point of the nanobond project (see http://www.nanobond.org/ online) has been the existing surface activating polymer and non-leaching, antimicrobial coating technology developed by devan and dppt. the project aimed at the development of a sustainable surface activation technology based on the self-assembly power of a 'soft nano-technology' for the development of versatile, highly functional textile products adapted to the needs of consumers. the main emphasis has been on the development of inherently antimicrobial and multifunctional textiles due to the advance of nosocomial diseases in europe. as alternative to commonly-used biocidal chemicals that are deliberately released from articles or surfaces and that are potentially environmentally harmful, we developed a new surface modification concept to control surface microbial contamination, particularly the development of bacterial colonies and biofilms.   
  
 new surface activating polymers based on the reaction of amines with epichlorohydrin have been developed. for this purpose, a low molecular weight azetidinium compound has been developed that contains a new bi-functional coupler and that can be added to various amine containing polymers. by this approach azetidinium functional groups are attached to the polymer backbone in a more quantitative and controlled way. in addition, further hydrophilic groups are introduced in the polymer backbone, which increases the hydrophilic / hydrophobic ratio of the polymer. it was found that the newly developed polymers are easily dispersed in water, while the surface affinity is retained. this is an improvement with respect to previously known surface activating polymers which are more difficult to be dispersed in water. water solubility is an important aspect for textile finishing as textile treatment from solvents requires special facilities and is barely economically feasible in europe. the evaluation of the developed polymers with regard to their applicability into the industrial process has been proofed. thus, upscaling has been performed and the newly developed polymers have been applied onto textiles by the small and medium-sized enterprises (smes). first innovative textile products with improved antimicrobial activity have been developed by the smes.   
  
 further approaches to develop multifunctional textiles included the development of flame retardant polymers and the integration of carrier systems, in particular microcapsules which contain active agents (here: antimicrobial agents, fragrances and phase change materials). the potential of the developed flame retardant polymers with regard to their effectiveness was demonstrated. pre-treatment with surface activating polymers was found to improve uptake and fixation of microcapsules on textiles.   
  
 studies on the influence of the structure and conformation of the newly developed polymers on their antimicrobial activity were performed with respect to their membrane affinity using different phospholipid langmuir monolayer models and their inhibition potential against proliferation of e. coli, b. subtilis and s. aureus. the studies with the model membranes led to the result that micro-structural / conformational differences play a role in the interactions of polymers with the lipid layer. furthermore, a structure-property relationship was established by analysing the antimicrobial activity of the polymers against e. coli, b. subtilis and s. aureus as function of the length of the alkyl chains at constant ratio of alkyl to cationic groups.   
  
 the final result of the project is the development of a universal, sustainable surface activation technology based on soft nano-coatings derived from specialised polymers that can themselves either create functionalised surfaces, or can provide a durable template from which functional properties can be built for the development of versatile, highly functional textiles and other products adapted to the needs of consumers. the main emphasis has been on the development of inherently antimicrobial and multifunctional textiles. the background for this has been the actual need to prevent nosocomial diseases in hospitals and nursing homes etc. considerations of the safety of users, environmental damage and cost mitigated the 'over-treatment' approach and, thus, the focus has been on the development of non-leaching permanent antimicrobial coatings applicable to different types of textiles and non fibrous materials.   
  
 the assurance of high durability of the textiles treated in the developed process leads to a reduction in performance costs.   
  
 project context and objectives:   
  
 whilst the traditional european textile industry has experienced increasing competition from low-cost manufacturing countries, a new prosperous technical textile industry has grown, representing high value, technological manufacturers and producers. these companies remain economically viable because of the significant inputs of technical and quality elements that are more readily absorbed by the high-end applications in which their products and processes are used. furthermore, technical textiles constitute an enabling technology for other important industries, e.g. light weight construction, automotive and medical technology.   
  
 yet also in this high end market, industries face a permanent pressure to remain competitive. evidently, continuous advancement of premium products alone may be not sufficient but industries must also refocus to medium- and low-tech large volume products by developing new, highly flexible production technologies and integrating fast feedback strategies along the production line from pre- to final products to rapidly respond to market demand. such flexible production technologies must overcome the economic dilemmas between efficient large scale production and customer oriented product diversification on one side and minimum complexity versus elaborate optimisation of production processes on the other side.   
  
 this project addressed competitiveness in fibre and textile refinement in high wage european countries by the development of a technology that comprises easy diversification, fast adaptability, efficient use of recourses, and reduced complexity. the technology has been designed to be integrated in existing production lines and it is supported by a 'pull through' business model where the benefits of the technology are demonstrated on finished products in order to create a market pull situation through the production chain. the most important area of activity has been the technical development of products and processes for reducing contamination with microbes from manufactured articles, including textiles, during use. in the first line, this is necessary for health reasons, but also for maintaining performance and function of technical textiles. nevertheless, by prolonging the useful life of an article, significant environmental benefits accrue, from the reduction in waste and the requirement for reduced cleaning in terms of frequency and energy / water use. thus, easy-to-clean, soil release and antimicrobial properties are linked aspects that are of great importance affecting comfort and freshness in consumer apparel, reduction of spoilage or wastage during storage and transport, increase of the useful lifetime of articles, maintenance of health and avoidance of cross-contamination in medical textiles. these benefits further contribute to the overall goals of sustainable product development, and, through reducing in-built disposability, to reducing energy demands and the protection of our water resources. another key area focuses on promoting adhesion in composite products with tailored mechanical and light weight properties.   
  
 the approach followed in this project has been based on a multifunctional bonding concept and does not rely on nano-particulates, but rather on molecular structuring at the nano-scale. it comprised the following:   
  
 - adaptability to a wide range of consumer and industrial applications   
 the bonding technology can be extendible to use on any surface where performance properties may be required to maintain functionality in use. there are many similarities between textile surface properties and those of paper, leather and wood. multi-functional performance of those substrates are also hot topics, for example, paper filters, leather for shoes and gloves, wood structures to be preserved from bad weather conditions. the developed surface activation technology can be 'spinned-off' to those related industries.   
  
 - highly-tailored solutions by altering the characteristics of the polymeric nano-film   
 the nanobond project exploits self organisation to create nano-structured and functional surfaces that can impart multiple beneficial properties, or provide a template for anchoring further functional finishes. examples include moisture management, fire retardancy, ultraviolet (uv).   
  
 - a responsive technology that adapts to the particular requirement for antimicrobial effect without 'swamping' the environment with the un-restrained release of antimicrobial agents, which is typical of other antimicrobial technologies   
 the nanobond technology, combined with an organo-silane antimicrobial product, creates an antimicrobial surface that functions by a physical rather than a chemical mode of action. thus, antimicrobial performance is proportionated to specific needs, whether it is for apparel or for medical textiles or devices.   
  
 - durability and effectiveness for the life of the goods has been clearly an important aspect in defining the sustainability credentials of the project. articles treated with the nanobond / antimicrobial technology have a longer natural lifetime through protection against damage and spoilage. thus, the initial cost of protection can be recouped through the increased longevity of treated articles.   
  
 - low application levels during processing, to attain maximal performance and limiting the potential for release of chemical products   
 the permanent binding of the chemical finishes to textile surfaces further reduces the potential environmental harm because no chemical products are released to the environment during use, including laundering. the surface-bound nano-film approach to the development of performance finishes thus addresses important ecological issues.   
  
 - easy application of the proposed technologies which will be integrated into the so-called 'wet processing' and does not require extensive modification or capital investment in expensive, sophisticated plant such as vacuum or corona machinery   
 the novel technology was developed specifically to make use of the type of equipment classically employed and widely available in textile processing mills, including in smes, providing a drop-in technology. thus, the time to market for these technologies, once developed, is rapid and brings a high-tech concept to a traditional industry without significant cost. this is one of the major benefits of this development. as a consequence of the technical achievements to be realised in the nanobond project, devan and dppt established a technological platform to which the other sme partners have access to develop their prototypes and to be trained in the use of the technologies. this platform is used as a pilot line to demonstrate the significant reduction in the time from laboratory studies to prototyping with an ultimate target 'less than 15 days'.   
  
 - the technology will be licensed to end-users under a process know-how technology transfer arrangement and devan will manufacture and sell the developed chemicals. industrial partners in the consortium will receive a free licence to use the technology in their respective field(s) of application. the licensing approach has two major advantages: good protection of the know-how and effective transfer of the technology to the user smes for optimum application. the licence fee will include the cost of education and training and royalties will be included in the chemical product prices.   
  
 - the focus on the differentiation between consumer groups (like sick people, older people, travelling people, sportspersons etc.) is in the responsibility of each sme in function of its respective market. whilst, dcs and i-care are able to focus the development of their products to the needs of individual consumers, the strategy of the other sme's is to develop differentiated products for diverse end-user groups which offers a degree of choice from a range of options. the technology allows easier integration of multi-functional properties. this means also that the smes differentiate their products not only from the competition but also have the ability to tailor products in function of the target consumer group.   
  
 in summary, the nanobond project aimed to develop a sustainable surface activation technology based on the self-assembly power of a 'soft nano-technology' for the development of versatile, highly functional textile products adapted to the needs of consumers. the main emphasis has been on the development of inherently antimicrobial and multi-functional textiles. as an alternative to commonly-used biocidal chemicals that are deliberately released from articles or surfaces and that are potentially environmentally harmful, a new surface modification concept to control surface microbial contamination, particularly the development of bacterial colonies and biofilms was proposed. this concept addresses:   
 (i) the adhesion of the microbial organisms to a surface;   
 (ii) the interruption of the biological functions that are vital for bacterial proliferation;   
 (iii) killing or controlling the microbial organisms that come into contact with the functional surface.   
 beyond this, nanobond addressed also products and applications such as adhesion in composite products and non fibrous materials.   
  
 project results:   
  
 as mentioned above, easy to clean, soil-release, soft touch and antimicrobial properties are linked aspects that are of great importance in sustainable product development, to save energy, ensure hygienic use and to protect our water resources from undesired contamination. such properties can be obtained through surface functionalisation. many surfaces, however, have no or only small numbers of reactive groups, thus the introduction of any functionality requires their prior activation. the typical method of surface activation is by 'physical' treatments using plasma or corona discharge, or in combination with, or as a pre-treatment for, chemical treatments. such processes however, imply costly new equipment investment, the use of either vacuum (high energy cost) or an inert gas (cost and energy) or atmospheric costs (e.g. generation of ozone). also, many of these treatments lead to unwanted changes in textile properties, such as an adverse change in handle or a reduction in strength.   
  
 in this field, the nanobond technology offers a more versatile alternative to a variety of application-specific methods for the fabrication of functional surfaces. the method applied in the project comprises the development of widely applicable covalently attached nano-coatings derived from specialised polymers that can themselves either create functionalised surfaces, or can provide a durable template from which functional properties can be built.   
  
 the basis of the research in nanobond focused on an a universal technology that will be applicable not only to flexible surfaces like polymers, foams, leather or paper but also to any hard surface like wood, concrete, metals, etc. additionally, as it was planned to follow the 'drop in' technology approach, the use of processes and substances developed in the project will not require investments into sophisticated equipment from users. as the result, the time to market of products finished using new technology will be short.   
  
 one of the important surface modifications, which were studied in detail in the project, was prevention against build-up of bio-films on surfaces (antimicrobial). consumer articles - including textiles - treated with antimicrobial agents are now widely available, and the use of antimicrobials increases the serviceability and longevity of treated articles. in addition, there are clearly potential comfort and aesthetic benefits, as well as health benefits in appropriate circumstances, for example for textile materials used in a variety of medical applications. but there are a number of key issues concerning effectiveness, human safety and environmental impact that must be addressed when considering the widespread use of such antimicrobial technologies. the maintenance of effectiveness after multiple uses and laundering is clearly a requirement of treated articles for the consumer, from the point of view of value for money and in terms of continuing to provide a performance benefit. the maintenance of effectiveness is of even more importance when considering medical textiles.   
  
 the most common approach to resolving the question of durability is to apply a high loading of the antimicrobial chemical to the treated article, by some means. during use, such compounds are leached from the article, a necessary process upon which their effectiveness relies as these compounds must be taken up or absorbed by micro-organisms. however, the compounds leached from the treated article in use - and during laundering - present unnecessary hazards. in terms of human health, the antimicrobial agent will cause destruction of harmless (indeed, beneficial) bacteria on the skin of the user. from an environmental viewpoint, uncontrolled release of antimicrobial agents into waste waters can have an adverse effect on effluent treatment plants, for example. furthermore, release of antimicrobial chemicals in such a manner implies a finite effective life, which will vary considerably depending on the initial loading factor. in short, a more controlled and responsive technology is required, where the uncontrolled release of antimicrobial chemicals into the environment is avoided.   
  
 in the nanobond project, considerations of the safety of users, environmental damage and cost mitigate the 'over-treatment' approach and, thus, it was focused on the development of non-leaching permanent antimicrobial coatings applicable to different types of textiles and non fibrous materials.   
  
 the consortium possesses a non-leaching antimicrobial technology used for textiles based on the organo-silane compound commercialised as aegis, which formed the reference to the studies. the textiles finished with this compound show good resistance against a broad spectrum of gram-positive and gram-negative bacteria, as well as fungi (mould, mildew) yeasts and algae. the anti-fungal activity indirectly provides treated textiles with protection against house dust mites, an important allergic trigger for many people. whilst sufficient for some applications, the durability of the coating needed to be increased for some applications, particularly use in medical textiles.   
  
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 the goal of the project has been the integration of new knowledge on nano- and material technologies with conventional production technologies in the traditional textile finishing sector and in textile cleaning, polymer processing and other industries.   
  
 the outcome of the project is a new concept in nano-structured polymeric coatings, which represents a novel application of 'soft nanotechnology'. these nano-structured coatings provide an activated surface for the further functionalisation of all textile goods to impart beneficial performance and health properties. the consortium has practical evidence to show that a functionalised polyether forms a coating on a textile surface that orients in such a way as to influence the surface properties of the textile fibre. it is known that there is an interaction between this polymer and an organo-silane with antimicrobial function, but the nature of that interaction is not known, and can be optimised by developing such an understanding. the organo-silane undergoes a self-polymerisation (condensation) on surfaces; it is believed that when co-applied, the structure of functionalised polyether may influence this self-polymerisation, which leads to an unexpected increase in antimicrobial performance and durability. in addition, other performance characteristics relating to comfort, health, aesthetics and sustainability may be introduced by using the nano-coating as a platform or template for further specific functionalisation. these surface modifications are considered to be 'passive' - there is no change in the basic form or function of the textile material, but the applied technology (antimicrobial, moisture management, fire resistance etc.) responds to a specific need and the localised environment in an appropriate way. the durability of the surface modifying nano-coating enables permanent performance benefits to be imparted for the life of the treated article, so increasing the useful life and sustainability of textile products. furthermore, the bonded technology, in particular the developed coupler-modified polymers, ensure that no chemicals are released during use, reducing or eliminating the potential impact on human health and environmental safety.   
  
 the project integrated partners from a number of scientific disciplines and different end-user requirements, including those specialised in textile chemical applications, surface science, polymer synthesis, and end-users requiring specific high-tech solutions to issues relating to the microbial contamination of textile surfaces, as well as other performance requirements. the project outcomes provide commercial opportunities in a wide range of consumer-oriented goods, including apparel, sportswear and bedding, and in more specialised applications requiring a highly-tailored technical solution such as textiles for patient wear in hospitals and in foam 'comfort' pads. however, a common requirement of the smes is their need for high-performance technical solutions to maintain their competitiveness and innovative lead over inferior technologies from outside the eu.   
  
 the nano-coating technology requires an understanding of the surface properties of functional polymers and their interactions with other functional materials such as antimicrobials. optimisation of the effects requires the design and manufacture of novel functional polymers encompassing the results of the early surface science studies. a key feature of the technology has been that it has been actually designed as a 'drop-in' technology. it is capable of application in conventional textile processing routes, not requiring investment in equipment or training. thus, the technologies are capable of rapid implementation and integration into existing manufacturing processes.   
  
 the european textiles and clothing sector has suffered a drastic decline in activity in recent years, and continues to face intense competition from low-wage economies, particularly china and other asian countries (see http://ec.europa.eu/enterprise/textile online). nevertheless, considerable economic activity remains in the eu, concentrated on highly technical smes, representing a total turnover of 132 billion and a workforce of 1.83 million persons in 2011 (see http://www.euratex.org/news-and-publications/29 online). in 2011, there were about 146 000 companies within the eu-27 boundaries involved in the industry, of which 96 % are classified as smes (euratex). the textile and clothing sector represents approx. 5 % of the jobs in the european manufacturing industry with an essential contribution of a female workforce (see http://www.etuf-tcl.org/index.php?s=6&rs=home&uid=689&lg=en#media online). european universities and research institutes also remain strong in the sciences and engineering related to the textile industry. for the sector to continue as a major revenue generator for the eu region, it must adapt and move towards technology- and knowledge-driven solutions in products and processes.   
  
 the market for technical textiles continues to develop and in these less price-sensitive applications the european industry is better able to compete, not only in terms of costs but, more importantly, in terms of technical ability, creativity and innovation. within the category of technical textiles may be considered applications such as health-care, construction, geotextiles, protective clothing; in addition, with ever increasing demands by consumers for performance-enhancing clothing, we may also include sportswear, work-wear and other performance apparel in this category.   
  
 the global market for technical textiles was estimated to be worth 80 billion in 2005. a press release of euratex aisbl from 18 june 2012 stated that the eu technical textile industry is a key development field for europe, able to service world market(s) of more than 100 billions provided true worldwide market access is guaranteed and innovation is fostered in eu (see http://www.euratex.org/news-and-publications/29 online). the principal external markets are the united states, switzerland and turkey. the main producers of technical textiles within europe are, in order, germany, the united kingdom, france, belgium and italy, the majority of which have been represented in this project.   
  
 it is clear that the strategic direction of the european textile industry must be towards developing solutions in these high added-value applications, which even so will require constant innovation to maintain a lead over the competitor regions. companies involved in technical textiles invest a far higher proportion of turn-over in r&d (8-10 %), compared with a textile industry average (3-5 %) in order to remain competitive and such investment must increasingly be focussed on highly targeted r&d, working in close collaboration with eu universities and research centres to retain the technical lead that europe presently enjoys over its competitors.   
  
 societal impacts of the project   
  
 general   
  
 the industrialised textile industry has been located historically in certain regions in europe and over the intervening period - during the last 200 years - this industrial activity was integrated into the social and cultural texture of the region and contributed strongly to its social and economical development. certain regions became synonymous with distinct products of the textile industry, in particular through the marketing of high quality technical and fashionable products. these were important contributors to the eu balance of trade with the export of high added-value products. as the mass-production textile industry has declined in europe, large-scale employment prospects have also diminished, but it is essential to retain significant levels of employment in the new, forward-looking niche market sectors of the industry. the importance of these high added-value niche applications has increased, and the continuation of the industry will increasingly rely on the transformation of the skills base in these traditional textile-producing regions.   
  
 the project addresses the most important community societal objectives, as summarised below.   
  
 employment   
 technologies were developed suitable for high added-value textile applications which are m ...

# NANOBOND

Project Acronym: NANOBOND

programme & topic: FP7-NMP NMP-2008-4.0-7

Most frequent returning words in objectives:

* ('technology', 36)
* ('surface', 35)
* ('textile', 35)
* ('textiles', 33)
* ('project', 32)
* ('development', 30)
* ('products', 27)
* ('polymers', 22)
* ('properties', 19)
* ('developed', 19)
* ('performance', 17)
* ('industry', 16)
* ('applications', 15)
* ('technologies', 15)
* ('surfaces', 14)
* ('polymer', 13)
* ('activity', 12)
* ('nanobond', 11)
* ('market', 11)
* ('chemical', 10)
* ('articles', 10)
* ('coatings', 10)
* ('processes', 10)
* ('materials', 9)

the idea of the nanobond project comprised the development of a system consisting of:   
 (i) the chemical activation of the fibre surface with a polymeric nano-coating for durable binding of functional molecules;   
 (ii) the effective incorporation of a selected functional finish for permanent modification of the textile properties, in the first instance a non-leaching antimicrobial agent;   
 (iii) the development of a universal technology applicable at any type of textiles and non fibrous materials.   
  
 the practical starting point of the nanobond project (see http://www.nanobond.org/ online) has been the existing surface activating polymer and non-leaching, antimicrobial coating technology developed by devan and dppt. the project aimed at the development of a sustainable surface activation technology based on the self-assembly power of a 'soft nano-technology' for the development of versatile, highly functional textile products adapted to the needs of consumers. the main emphasis has been on the development of inherently antimicrobial and multifunctional textiles due to the advance of nosocomial diseases in europe. as alternative to commonly-used biocidal chemicals that are deliberately released from articles or surfaces and that are potentially environmentally harmful, we developed a new surface modification concept to control surface microbial contamination, particularly the development of bacterial colonies and biofilms.   
  
 new surface activating polymers based on the reaction of amines with epichlorohydrin have been developed. for this purpose, a low molecular weight azetidinium compound has been developed that contains a new bi-functional coupler and that can be added to various amine containing polymers. by this approach azetidinium functional groups are attached to the polymer backbone in a more quantitative and controlled way. in addition, further hydrophilic groups are introduced in the polymer backbone, which increases the hydrophilic / hydrophobic ratio of the polymer. it was found that the newly developed polymers are easily dispersed in water, while the surface affinity is retained. this is an improvement with respect to previously known surface activating polymers which are more difficult to be dispersed in water. water solubility is an important aspect for textile finishing as textile treatment from solvents requires special facilities and is barely economically feasible in europe. the evaluation of the developed polymers with regard to their applicability into the industrial process has been proofed. thus, upscaling has been performed and the newly developed polymers have been applied onto textiles by the small and medium-sized enterprises (smes). first innovative textile products with improved antimicrobial activity have been developed by the smes.   
  
 further approaches to develop multifunctional textiles included the development of flame retardant polymers and the integration of carrier systems, in particular microcapsules which contain active agents (here: antimicrobial agents, fragrances and phase change materials). the potential of the developed flame retardant polymers with regard to their effectiveness was demonstrated. pre-treatment with surface activating polymers was found to improve uptake and fixation of microcapsules on textiles.   
  
 studies on the influence of the structure and conformation of the newly developed polymers on their antimicrobial activity were performed with respect to their membrane affinity using different phospholipid langmuir monolayer models and their inhibition potential against proliferation of e. coli, b. subtilis and s. aureus. the studies with the model membranes led to the result that micro-structural / conformational differences play a role in the interactions of polymers with the lipid layer. furthermore, a structure-property relationship was established by analysing the antimicrobial activity of the polymers against e. coli, b. subtilis and s. aureus as function of the length of the alkyl chains at constant ratio of alkyl to cationic groups.   
  
 the final result of the project is the development of a universal, sustainable surface activation technology based on soft nano-coatings derived from specialised polymers that can themselves either create functionalised surfaces, or can provide a durable template from which functional properties can be built for the development of versatile, highly functional textiles and other products adapted to the needs of consumers. the main emphasis has been on the development of inherently antimicrobial and multifunctional textiles. the background for this has been the actual need to prevent nosocomial diseases in hospitals and nursing homes etc. considerations of the safety of users, environmental damage and cost mitigated the 'over-treatment' approach and, thus, the focus has been on the development of non-leaching permanent antimicrobial coatings applicable to different types of textiles and non fibrous materials.   
  
 the assurance of high durability of the textiles treated in the developed process leads to a reduction in performance costs.   
  
 project context and objectives:   
  
 whilst the traditional european textile industry has experienced increasing competition from low-cost manufacturing countries, a new prosperous technical textile industry has grown, representing high value, technological manufacturers and producers. these companies remain economically viable because of the significant inputs of technical and quality elements that are more readily absorbed by the high-end applications in which their products and processes are used. furthermore, technical textiles constitute an enabling technology for other important industries, e.g. light weight construction, automotive and medical technology.   
  
 yet also in this high end market, industries face a permanent pressure to remain competitive. evidently, continuous advancement of premium products alone may be not sufficient but industries must also refocus to medium- and low-tech large volume products by developing new, highly flexible production technologies and integrating fast feedback strategies along the production line from pre- to final products to rapidly respond to market demand. such flexible production technologies must overcome the economic dilemmas between efficient large scale production and customer oriented product diversification on one side and minimum complexity versus elaborate optimisation of production processes on the other side.   
  
 this project addressed competitiveness in fibre and textile refinement in high wage european countries by the development of a technology that comprises easy diversification, fast adaptability, efficient use of recourses, and reduced complexity. the technology has been designed to be integrated in existing production lines and it is supported by a 'pull through' business model where the benefits of the technology are demonstrated on finished products in order to create a market pull situation through the production chain. the most important area of activity has been the technical development of products and processes for reducing contamination with microbes from manufactured articles, including textiles, during use. in the first line, this is necessary for health reasons, but also for maintaining performance and function of technical textiles. nevertheless, by prolonging the useful life of an article, significant environmental benefits accrue, from the reduction in waste and the requirement for reduced cleaning in terms of frequency and energy / water use. thus, easy-to-clean, soil release and antimicrobial properties are linked aspects that are of great importance affecting comfort and freshness in consumer apparel, reduction of spoilage or wastage during storage and transport, increase of the useful lifetime of articles, maintenance of health and avoidance of cross-contamination in medical textiles. these benefits further contribute to the overall goals of sustainable product development, and, through reducing in-built disposability, to reducing energy demands and the protection of our water resources. another key area focuses on promoting adhesion in composite products with tailored mechanical and light weight properties.   
  
 the approach followed in this project has been based on a multifunctional bonding concept and does not rely on nano-particulates, but rather on molecular structuring at the nano-scale. it comprised the following:   
  
 - adaptability to a wide range of consumer and industrial applications   
 the bonding technology can be extendible to use on any surface where performance properties may be required to maintain functionality in use. there are many similarities between textile surface properties and those of paper, leather and wood. multi-functional performance of those substrates are also hot topics, for example, paper filters, leather for shoes and gloves, wood structures to be preserved from bad weather conditions. the developed surface activation technology can be 'spinned-off' to those related industries.   
  
 - highly-tailored solutions by altering the characteristics of the polymeric nano-film   
 the nanobond project exploits self organisation to create nano-structured and functional surfaces that can impart multiple beneficial properties, or provide a template for anchoring further functional finishes. examples include moisture management, fire retardancy, ultraviolet (uv).   
  
 - a responsive technology that adapts to the particular requirement for antimicrobial effect without 'swamping' the environment with the un-restrained release of antimicrobial agents, which is typical of other antimicrobial technologies   
 the nanobond technology, combined with an organo-silane antimicrobial product, creates an antimicrobial surface that functions by a physical rather than a chemical mode of action. thus, antimicrobial performance is proportionated to specific needs, whether it is for apparel or for medical textiles or devices.   
  
 - durability and effectiveness for the life of the goods has been clearly an important aspect in defining the sustainability credentials of the project. articles treated with the nanobond / antimicrobial technology have a longer natural lifetime through protection against damage and spoilage. thus, the initial cost of protection can be recouped through the increased longevity of treated articles.   
  
 - low application levels during processing, to attain maximal performance and limiting the potential for release of chemical products   
 the permanent binding of the chemical finishes to textile surfaces further reduces the potential environmental harm because no chemical products are released to the environment during use, including laundering. the surface-bound nano-film approach to the development of performance finishes thus addresses important ecological issues.   
  
 - easy application of the proposed technologies which will be integrated into the so-called 'wet processing' and does not require extensive modification or capital investment in expensive, sophisticated plant such as vacuum or corona machinery   
 the novel technology was developed specifically to make use of the type of equipment classically employed and widely available in textile processing mills, including in smes, providing a drop-in technology. thus, the time to market for these technologies, once developed, is rapid and brings a high-tech concept to a traditional industry without significant cost. this is one of the major benefits of this development. as a consequence of the technical achievements to be realised in the nanobond project, devan and dppt established a technological platform to which the other sme partners have access to develop their prototypes and to be trained in the use of the technologies. this platform is used as a pilot line to demonstrate the significant reduction in the time from laboratory studies to prototyping with an ultimate target 'less than 15 days'.   
  
 - the technology will be licensed to end-users under a process know-how technology transfer arrangement and devan will manufacture and sell the developed chemicals. industrial partners in the consortium will receive a free licence to use the technology in their respective field(s) of application. the licensing approach has two major advantages: good protection of the know-how and effective transfer of the technology to the user smes for optimum application. the licence fee will include the cost of education and training and royalties will be included in the chemical product prices.   
  
 - the focus on the differentiation between consumer groups (like sick people, older people, travelling people, sportspersons etc.) is in the responsibility of each sme in function of its respective market. whilst, dcs and i-care are able to focus the development of their products to the needs of individual consumers, the strategy of the other sme's is to develop differentiated products for diverse end-user groups which offers a degree of choice from a range of options. the technology allows easier integration of multi-functional properties. this means also that the smes differentiate their products not only from the competition but also have the ability to tailor products in function of the target consumer group.   
  
 in summary, the nanobond project aimed to develop a sustainable surface activation technology based on the self-assembly power of a 'soft nano-technology' for the development of versatile, highly functional textile products adapted to the needs of consumers. the main emphasis has been on the development of inherently antimicrobial and multi-functional textiles. as an alternative to commonly-used biocidal chemicals that are deliberately released from articles or surfaces and that are potentially environmentally harmful, a new surface modification concept to control surface microbial contamination, particularly the development of bacterial colonies and biofilms was proposed. this concept addresses:   
 (i) the adhesion of the microbial organisms to a surface;   
 (ii) the interruption of the biological functions that are vital for bacterial proliferation;   
 (iii) killing or controlling the microbial organisms that come into contact with the functional surface.   
 beyond this, nanobond addressed also products and applications such as adhesion in composite products and non fibrous materials.   
  
 project results:   
  
 as mentioned above, easy to clean, soil-release, soft touch and antimicrobial properties are linked aspects that are of great importance in sustainable product development, to save energy, ensure hygienic use and to protect our water resources from undesired contamination. such properties can be obtained through surface functionalisation. many surfaces, however, have no or only small numbers of reactive groups, thus the introduction of any functionality requires their prior activation. the typical method of surface activation is by 'physical' treatments using plasma or corona discharge, or in combination with, or as a pre-treatment for, chemical treatments. such processes however, imply costly new equipment investment, the use of either vacuum (high energy cost) or an inert gas (cost and energy) or atmospheric costs (e.g. generation of ozone). also, many of these treatments lead to unwanted changes in textile properties, such as an adverse change in handle or a reduction in strength.   
  
 in this field, the nanobond technology offers a more versatile alternative to a variety of application-specific methods for the fabrication of functional surfaces. the method applied in the project comprises the development of widely applicable covalently attached nano-coatings derived from specialised polymers that can themselves either create functionalised surfaces, or can provide a durable template from which functional properties can be built.   
  
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 through this project, the development of such coatings which will be stable on washing up to 100 or more washing cycles at elevated temperatures (at least 60 degrees celsius) was planned. this should be achieved by detailed studies of the mechanisms which govern the adsorption / desorption processes of the surface activating polymer and antimicrobial agent. the assurance of such durability is very important in case of bedclothes for hospitals or hotels, surgeons' gowns and nurses' uniforms. these textiles need to be washed very often and if not sufficiently protected will lose their protective properties quickly and will be discarded which will lead to an increase in costs.   
  
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 the project aimed to develop new knowledge-based technologies that address the need to enhance the technical performance of consumer articles, particularly apparel, sportswear and bedding. further applications of the technology were to be evaluated in polymeric materials such as pu-foams for hospital or institutional applications and in textiles such as patient gowns for hospital use. industrial (sme) partners active in the full range of these fields of application have been key participants in the project aiming at an incorporation of the developed technologies into their manufacturing processes or at the dissemination of the technology to other high-end users in selected industries. the project coordinator has been a research and development (r&d)-led company involved in developing highly-specialised chemical technologies for the textile industry. the project concept originated from the coordinating sme, which intended to develop a greater understanding of the influence of nano-coatings and to broaden their applicability. the research and technological development (rtd) partners have been chosen specifically because of their high level of sophistication in researching nano-coatings, polymers, antimicrobials and related topics. the other sme partners have been selected because of their involvement in the development of consumer products with a high technical content that allows differentiation from low-value mass-market goods. furthermore, the outcomes of the project are applicable to medical textile products, where the need to impart specific performance such as antimicrobial behaviour is important to the quality and functionality of the goods. the other goal has been the transfer of the technology from textiles to the development of a new universal tool to finishing of non-fibrous elastic materials as well as the finishing of hard surfaces like paper, wood or leather.   
  
 the goal of the project has been the integration of new knowledge on nano- and material technologies with conventional production technologies in the traditional textile finishing sector and in textile cleaning, polymer processing and other industries.   
  
 the outcome of the project is a new concept in nano-structured polymeric coatings, which represents a novel application of 'soft nanotechnology'. these nano-structured coatings provide an activated surface for the further functionalisation of all textile goods to impart beneficial performance and health properties. the consortium has practical evidence to show that a functionalised polyether forms a coating on a textile surface that orients in such a way as to influence the surface properties of the textile fibre. it is known that there is an interaction between this polymer and an organo-silane with antimicrobial function, but the nature of that interaction is not known, and can be optimised by developing such an understanding. the organo-silane undergoes a self-polymerisation (condensation) on surfaces; it is believed that when co-applied, the structure of functionalised polyether may influence this self-polymerisation, which leads to an unexpected increase in antimicrobial performance and durability. in addition, other performance characteristics relating to comfort, health, aesthetics and sustainability may be introduced by using the nano-coating as a platform or template for further specific functionalisation. these surface modifications are considered to be 'passive' - there is no change in the basic form or function of the textile material, but the applied technology (antimicrobial, moisture management, fire resistance etc.) responds to a specific need and the localised environment in an appropriate way. the durability of the surface modifying nano-coating enables permanent performance benefits to be imparted for the life of the treated article, so increasing the useful life and sustainability of textile products. furthermore, the bonded technology, in particular the developed coupler-modified polymers, ensure that no chemicals are released during use, reducing or eliminating the potential impact on human health and environmental safety.   
  
 the project integrated partners from a number of scientific disciplines and different end-user requirements, including those specialised in textile chemical applications, surface science, polymer synthesis, and end-users requiring specific high-tech solutions to issues relating to the microbial contamination of textile surfaces, as well as other performance requirements. the project outcomes provide commercial opportunities in a wide range of consumer-oriented goods, including apparel, sportswear and bedding, and in more specialised applications requiring a highly-tailored technical solution such as textiles for patient wear in hospitals and in foam 'comfort' pads. however, a common requirement of the smes is their need for high-performance technical solutions to maintain their competitiveness and innovative lead over inferior technologies from outside the eu.   
  
 the nano-coating technology requires an understanding of the surface properties of functional polymers and their interactions with other functional materials such as antimicrobials. optimisation of the effects requires the design and manufacture of novel functional polymers encompassing the results of the early surface science studies. a key feature of the technology has been that it has been actually designed as a 'drop-in' technology. it is capable of application in conventional textile processing routes, not requiring investment in equipment or training. thus, the technologies are capable of rapid implementation and integration into existing manufacturing processes.   
  
 the european textiles and clothing sector has suffered a drastic decline in activity in recent years, and continues to face intense competition from low-wage economies, particularly china and other asian countries (see http://ec.europa.eu/enterprise/textile online). nevertheless, considerable economic activity remains in the eu, concentrated on highly technical smes, representing a total turnover of 132 billion and a workforce of 1.83 million persons in 2011 (see http://www.euratex.org/news-and-publications/29 online). in 2011, there were about 146 000 companies within the eu-27 boundaries involved in the industry, of which 96 % are classified as smes (euratex). the textile and clothing sector represents approx. 5 % of the jobs in the european manufacturing industry with an essential contribution of a female workforce (see http://www.etuf-tcl.org/index.php?s=6&rs=home&uid=689&lg=en#media online). european universities and research institutes also remain strong in the sciences and engineering related to the textile industry. for the sector to continue as a major revenue generator for the eu region, it must adapt and move towards technology- and knowledge-driven solutions in products and processes.   
  
 the market for technical textiles continues to develop and in these less price-sensitive applications the european industry is better able to compete, not only in terms of costs but, more importantly, in terms of technical ability, creativity and innovation. within the category of technical textiles may be considered applications such as health-care, construction, geotextiles, protective clothing; in addition, with ever increasing demands by consumers for performance-enhancing clothing, we may also include sportswear, work-wear and other performance apparel in this category.   
  
 the global market for technical textiles was estimated to be worth 80 billion in 2005. a press release of euratex aisbl from 18 june 2012 stated that the eu technical textile industry is a key development field for europe, able to service world market(s) of more than 100 billions provided true worldwide market access is guaranteed and innovation is fostered in eu (see http://www.euratex.org/news-and-publications/29 online). the principal external markets are the united states, switzerland and turkey. the main producers of technical textiles within europe are, in order, germany, the united kingdom, france, belgium and italy, the majority of which have been represented in this project.   
  
 it is clear that the strategic direction of the european textile industry must be towards developing solutions in these high added-value applications, which even so will require constant innovation to maintain a lead over the competitor regions. companies involved in technical textiles invest a far higher proportion of turn-over in r&d (8-10 %), compared with a textile industry average (3-5 %) in order to remain competitive and such investment must increasingly be focussed on highly targeted r&d, working in close collaboration with eu universities and research centres to retain the technical lead that europe presently enjoys over its competitors.   
  
 societal impacts of the project   
  
 general   
  
 the industrialised textile industry has been located historically in certain regions in europe and over the intervening period - during the last 200 years - this industrial activity was integrated into the social and cultural texture of the region and contributed strongly to its social and economical development. certain regions became synonymous with distinct products of the textile industry, in particular through the marketing of high quality technical and fashionable products. these were important contributors to the eu balance of trade with the export of high added-value products. as the mass-production textile industry has declined in europe, large-scale employment prospects have also diminished, but it is essential to retain significant levels of employment in the new, forward-looking niche market sectors of the industry. the importance of these high added-value niche applications has increased, and the continuation of the industry will increasingly rely on the transformation of the skills base in these traditional textile-producing regions.   
  
 the project addresses the most important community societal objectives, as summarised below.   
  
 employment   
 technologies were developed suitable for high added-value textile applications which are m ...

# MICROFLEX

Project Acronym: MICROFLEX

programme & topic: FP7-NMP NMP-2007-3.5-2

Most frequent returning words in objectives:

* ('project', 7)
* ('fabrics', 7)
* ('mems', 6)
* ('impact', 5)
* ('printing', 4)
* ('phase', 4)
* ('production', 3)
* ('inks', 3)
* ('textiles', 3)
* ('process', 3)
* ('specification', 3)
* ('ink/paste', 3)
* ('developments', 3)
* ('results', 3)
* ('structure', 3)
* ('objectives', 2)
* ('layer', 2)
* ('inkjet', 2)
* ('work', 2)
* ('prototypes', 2)
* ('development', 2)
* ('screen', 2)
* ('tests', 2)
* ('prototype', 2)

1.1 project objectives  
the objectives of the project are to develop a mems processing capability for the production of intelligent flexible fabrics/textiles. it will be composed of:  
(1) processes and inks for the deposition of layers on textiles  
(2) a three and five sacrificial layer process for the thick film production of surface micromachined 3d mems on textiles and fabrics  
(3) a sacrificial layer and additive layering process for the inkjet production of 3d mems on textiles and fabrics using inkjet printing  
(4) encapsulation process  
  
1.2 work performed since the beginning of the project  
work has been completed on the specification of the phase 1 and phase 2 prototypes, the ink/paste developments needed, the ink/paste specifications and the design of mems compatible with fabrics. the recommendations and summary of the reach directive was provided to all the partners in order to have the development of sustainable products. preliminary ink jet and screen printing tests have been undertaken and an initial prototype has been realised. ink/paste development has been undertaken. the designs of the mems have been completed and summarised in deliverable d8.  
  
1.3 main results achieved so far  
the main results so far are the specification of the phase 1 and phase 2 prototypes, the ink developments needed, the ink specification and all the mems designs. a number of bespoke inks and pastes have been realised. preliminary ink jet and screen printing tests have been undertaken and an initial prototype has been realised. a structure, an actuator structure and a sensor structure have also been realised on a fabric.  
  
1.4 expected final results and their potential impact and use (including the socio-economic impact and the wider societal implications of the project so far)  
we expect a family of inks/pastes proven to be compatible with the fabrics assessed in the project and potentially compatible with many other fabrics. we expect to demonstrate these ink/pastes on a range of application relevant to the end users in the project. these developments will have a positive economic impact through uptake of printing technology in other smart fabrics applications following the examples demonstrated in the project. there will be positive societal impact since the inks allow the achievement of socially beneficial smart fabrics (e.g. medical) whilst using the minimum of raw materials to achieve a positive environmental impact.

# STOREPET

Project Acronym: STOREPET

programme & topic: FP7-SME SME-2011-2

Most frequent returning words in objectives:

* ('storepet', 40)
* ('building', 25)
* ('insulation', 24)
* ('thermal', 23)
* ('energy', 16)
* ('product', 16)
* ('materials', 15)
* ('project', 13)
* ('heat', 13)
* ('production', 13)
* ('software', 13)
* ('material', 11)
* ('pcms', 11)
* ('market', 11)
* ('buildings', 10)
* ('lightweight', 10)
* ('phase', 9)
* ('panel', 9)
* ('fiber', 8)
* ('change', 8)
* ('fibers', 8)
* ('climate', 8)
* ('technology', 8)
* ('storage', 7)

executive summary:  
under the currently growing role for near-zero energy buildings, innovative lightweight structures has been one of the most interesting building technologies arising. while it represents an economical alternative to traditional heavyweight constructions, the main drawback of highly insulated lightweight envelopes is still their lack of thermal mass, which unable to curb and dampen rapid and marked daily temperature swings and maintain internal comfort conditions, especially during the summer in hot regions. this quick thermal response is especially significant during the warmer seasons and responsible for indoor overheating trends, forcing the costly peak period of energy consumption to be spent upon cooling rooms during the day. the storepet project was based upon the concept that potential cost savings could be achieved by smart envelope structures having a novel fiber insulation with active heat storage capacities. towards this aim, phase change materials (pcm) were selected as the material solution for being able to help this innovative insulation to reduce the total cooling loads and shift the peak loads to off-peak periods. following 3 years of intense research work, storepet product was developed as a ready-to-use and easy to install brand new insulation blanket, made with recycled polyester fibers and enhanced with a pcm content. the embedded pcm provides thermal inertia by means of its latent heat, while keeping relatively unchanged the high thermal resistance of the original nonwoven material.  
involving the fruitful collaboration of 4 sme-ags, 3 smes and 4 rtd institutions, different manufacturing technologies and pcm-fiber integration approaches were intensively researched at lab scale. following the testing and evaluation of more than 30 different types of pcms and 6 polymer compositions, several manufacturing routes were assessed, either involving the development of bi-component fibres systems with pcm cores using electrospinning and unique coaxial melt-spinning extrusion/injection techniques, or by means of spray deposition of microencapsulated pcms (mpcms) and flame retardant additives on the base nonwovens matrices. before entering the up-scaling production stage, many formulations were studied, laboratory tested and optimized in the early stages of the project work program. the right pcms were selected based upon many different factors including, indoor thermal comfort condition ranges, typical market location seasonal climates, melting/freezing phase transitions temperatures, latent heat ranks, supercooling, stability under multiple cycles trends, etc.. complementary, the research group developed dedicated modelling simulation tools to assist the right selection of the type and amount of pcm to reach the required thermal properties for different climate patterns. in result, base nonwoven panels made of recycled polyethylene terephthalate (pet) and having excellent insulating properties and eco-friendly status for being obtained from post-consume plastic bottles, were combined and coated by spray deposition in a controlled industrial environment upscaling program, with a special formulated organic microencapsulated pcms (mpcms) composition, which also included special additives like fixing elements and flame retardants.  
the storepet final product consisted on a layered 4.53kg/m2 and 85mm thick mpcm-fiber blanket solution. regarding the benefit effect of the heat storage capacity of the pcm content, hot-box tests proved to be possible for storepet to attain up to a 33% reduction in cooling demands, when compared with similar non-additivated panels, while still securing a lambda value around 0.04w/mk. moreover, 1 full year of comparative field tests made with two small buildings at the eu supported nanoe2b cluster demo park in spain, have revealed average internal temperature differences of around 1â°c during the day and 1.5â°c during the night, between the storepet building and the standard test building for a typical summer period. parallel energy consumption evaluations for the same period have also shown possible to reach reductions in the electric demand of around 40% for the storepet demo building.   
apart from being a ready to install product, a remarkable characteristic of storepet is the flexibility to produce tailor made products for different climate conditions and the versatility of its usage in all wall and roof lightweight building applications. also part of the research project, simulation tools have been developed, not only to aid in the pcm selection and amount required for different climate conditions/locations, but also to attest storepet efficiency of in many possible construction types, including ventilated faã§ade systems to promote the daily charging/ discharging cycle work of the pcm content. following the successful of the storepet project and having secured already a preliminary product life cycle assessment (lca) and most of the characterization needed towards ce marking and green labelling certification, the consortium is currently considering the right partnerships for the commercialization of this novel fiber insulation and make its market entrance in specific markets in a near future.  
  
project context and objectives:  
currently buildings account for 40% of the worldâs energy and almost half of the todayâs green house gas emissions. most of buildingsâ energy consumption presently used for heating, cooling and ventilation is still needlessly wasted due to the lack or inefficient insulation measures. taking into account the last european community regulatory and legislative actions, itâs estimated that global building sector needs to cut energy consumption in buildings 60% by 2050, in order to meet the global climate change targets. regarding the new buildings, universal trends now show a movement towards lightweight and modular timber or steel constructions (with less site wastes involved and lower embedded energy materials), with global demand for prefabricated housing and elements growing at 3.4 % per year, for a market valued at â¬51 billion in 2004 for complete buildings alone.   
although lightweight constructions represent an economical alternative to traditional buildings, one of their main drawbacks is their very high energy load needs to keep internal comfort conditions, as they are unable to curb rapid swings of temperature due to their lack of thermal mass using between 2 and 3 times the heating and cooling energy needed by a heavy weight material construction the main goal of the storepet project is to develop a new nonwoven technical insulation product that integrates phase change materials for heat storage capacity skills. maintaining the superior levels of thermal and noise insulation commonly recognized for fiber materials, storepet will be especially design to insulate new or refurbishing needing lightweight and low thermal mass building envelope structures.  
this way storepet aims to deliver to the construction market a new inexpensive thermally enhanced and âready to useâ pcm- fiber insulation based composite, that combines on a single product 3 major skills: thermal insulation abilities to block heat transfer into or out of the buildings, outstanding airborne sound control proficiency and now also thermal storage capacities. the versatility of the concept will make it adaptable for heating and cooling purposes, enabling this product to address different climate patterns and geographical markets just by tailoring its relative composition, dimensions and installation layout.  
the research aims to first noticeably identify the best technical fiber characteristics and which pcms materials and are most likely to be used for the purpose, based on the raw materials thermodynamic, chemical and physics properties evaluation with the aid of simulation software tools. secondly, develop the productâs design and the technology for the pcm-fiber integration and trial product manufacturing, aiming to combine the best final technical properties with an industrial up-scaling feasibility and the least embodied energy necessary for its production, using the most cost effective raw materials with the highest recycled content possible and least energy consuming production  
lines. itâs foreseen that storepet products will be able to secure a heat flow reduction in lab condition of about 40%, when compared with the same fiber material produced without the pcm content and guarantee similar reference values in terms of other thermal and acoustical properties and secure all the technical requirements to meet the national and communitarian building codes and regulations for each proposed entrance market. in terms of energy savings, it is expected to secure by field tests potential and significant cooling load reductions during a spring summer season periods representing real energy savings. although very dependable on the climate location during the evaluation tests, reference peak-hour load reductions values higher than 20% are expected and cooling-dominated loads reductions up to 40%, when compared with the simultaneously usage of non-pcm activated fiber insulation materials (mineral wool, glass wool, etc.).  
  
project results:  
the main goal of the storepet project is to develop a new nonwoven technical insulation product that integrates phase change materials for heat storage capacity skills. the project s&t results include the material insulation panel, its production technology and the simulation software which allows engineers and architect to choose the best pcm composition according to the geographical location of the lightweight building.   
  
1. the storepet insulation material: the final storepet product referred in this report consisted on a flexible double panel-like pcm-fiber layer solution that was produced in an industrial environment. the storepet insulation material is a flexible insulation nonwoven panel made of:  
â¢ 100% recycled polyethylene terephthalate (pet) fibers;  
â¢ thermo-regulating microencapsulated phase change materials (mpcms) and flame retardant coatings.  
the main important factor in the development of storepet is the choose of the most appropriate pcm for each location. organic pcms like paraffinic waxes and fatty acids both present phase changing temperatures around human comfortable range, making them suitable for building applications. paraffins are the mostly used organic heat storage pcms, but obtained from petroleum. alternatively, fatty acids and their esters derived from common vegetable and animal oils can provide an assurance of continuous supply of pcms, despite the shortage of fuel sources.  
â¢ paraffins (18-38âºc)  
â¢ fatty acids esters (22-34âºc)  
â¢ eutectic mixtures  
the product ecozeroâ® used as benchmark is a nonwoven thermal and acoustic insulation panel made of recycled polyester that has been used as raw component for the production of the storepet composite panel. the following table shows the technical features of insulation product storepet.  
  
product technical objectives goal achieved remarks  
heat flow reduction ~40% 33% very close to accomplish the objective   
noise transmission insulation â¥ 55 d/57 db 61 db objective exceeded  
thermal conductivity â¤ 0.04 w/(mk) 0.04 w/(mk) objective accomplished  
thermal resistance â¥ 2.5 m2k/w 2.5 m2k/w objective accomplished  
european fire classification class bs2d0 class bs1d0 objective accomplished  
  
2. the storepet production process: the production process required to manufacture storepet panels will depend on the pcm integration technology. the pcm integration technology will be chosen depending if the pcm will be integrated inside the fibers and outside the fibers. three process have been studied:  
a) coaxial melt extrusion/injection: with a brand new fiber melt-spun design integrated with pcm injection system, it is possible to manufacture bi-component fibers having only a pcm material in its core. the pcm is staunched inside the core and pet is sheath part of the fibers. the drawback is the difficulty to scale-up for a mass production at this moment since the technology is still under development.  
b)coaxial electrospinning: the electrospinning process allows us to create continuos fibers with diameters in the nanometer to the sub micrometer range. however, currently can not be used for the mass production of storepet due to its drawbacks: low production rate, not environmentally friendly (harmful polymer solvents) and difficult to up-scale.  
c) spraying deposition: this technology allows us to integrate pcm outside the fibers. it consists on spraying of the pcm over the pet panels. previously, it has been an optimization process of the distance between the nozzles and the panel and the panels themselves.  
  
3. the storepet simulation software: the storepet final product includes a software tool which allows engineers to know the panel performance and profitability in each specific case depending on the pcm used. "thermal building" software was developed during the project for the computation of the thermal performance of cuboid buildings with multilayer walls containing insulating panels with layers of phase change materials (pcm). the application can compute heat losses of a building (heating and cooling loads) and other parameters for user specified weather conditions. the software helps in making comparison of performance of the storepet insulating panels with traditional insulating materials.the input required by software are the thermal building features such as the solar irradiation that the walls received and the indoor climate conditions (free-floating, a/c or fixed temperature). the software calculates the wall's external and internal temperatures as well as the cooling and heating loads. from that outcomes, the pcm layers simulations is launched. the difference between energy released and absorbed by the panel is the effect of pcm phase change, due to the heat is converted into latent enthalpy. in addition, the storepet software takes into account the effect of hysteresis and subcooling which is neglected by all programs available in the market.  
  
the validation of these results was performed by means of real scale mock ups which were built in madrid (spain) to demonstrate phase change behaviour of storepet material. averaged peak to peak analysis revealed internal temperature differences of around 1âºc during the day and 1.5âºc during the night, between the storepet and the standard test-cells for a typical summer period. parallel energy consumption tests over cooling systems showed a reduction in the electrical demand of around 40% for the storepet demo building comparing to standard one having no pcms  
  
complmentary achievements: apart from the achievements related to the project results defined in dow, we have carried out complementary tasks which have allowed us to reach the following outcomes:  
â¢ defined possible climate patterns (market oriented) and suitable pcms for the each location  
â¢ produced diverse binary mixtures of organic pcms  
â¢ developed/assessed fire retardants for different pcm storepet applications  
â¢ defined a suitable set of tests for technical evaluation (heat flux tests) and assessed storepet product on-site in demo houses  
â¢ developed dedicated simulation tools including subcooling effects for the pcm action  
â¢ initiated the pre-market procedures : msds sheets; life cycle assessment; ce marking and green building certification  
â¢ envisaged multiple industrial scale up settings  
â¢ established industrial production collaborations for future exploitation  
â¢ promoted cluster integration since storepet has become a member of the eu advanced material and nanotechnology cluster (amanac) - nanoinsulation & hvac working group  
â¢ produced training material for future knowledge   
â¢ promoted storepet on multiple platforms (congresses, fairs, magazines, flyers, posters, internet, e-seminars, etc.)  
  
  
   
  
  
potential impact:  
economic and social impact: derived from the development of storepet products are summarized:  
storepet technology and products (including the software tool) will offer our members the opportunity to pursue new revenue streams from the manufacture and installation of this new thermal comfort system, in, at least, two potential construction markets: new lightweight building and retrofitting of older buildings.  
we have estimated that the overall lightweight building could have a rate of 7.48% from the total wall insulation market. the resulting constructor revenues would be of 12.50 mâ¬ and the whole supply chain revenues of 10.42â¬, which means total revenues of 22.91mâ¬. regarding profits, constructors would achieve earnings exceeding 2 mâ¬, supply chain 1.55mâ¬, what add a total profits of 3.64mâ¬. our forecasts for renovations of existing building will be 55% from the total wall insulation market. we have estimated over 90 mâ¬ revenues, 15mâ¬ benefits for constructors, 77 mâ¬ revenues and 11mâ¬ for the supply chain. as a result, we expect to achieve for retrofit market total revenues of almost 170mâ¬ and total profits of 26.95mâ¬.  
itâs expected that storepet will have a high positive impact on the environment due to the reduction of energy consumption. it is estimated that after 5 years of its commercialization, 785 gwh can be saved by heating consumers, meaning 364 million tonnes less of co2 to the atmosphere. in addition, this technology will contribute to the basis of a future european normative on building construction: determination of thermal storage capacity, standardization of thermal insulation in lightweight constructions and sound insulation, as well as more demanding national building codes.  
  
exploitation of the results:   
the consortium has designed a plan for the protection of ipr. this plan will start with a patentability study which will show us the most convenient protection for each result regarding the highest benefit for industrial partners within the consortium. however, we have agreed a first strategy based on the following issues:   
â¢ protection of coaxial melt spinning production process: we believe that this process has the novelty level required to grant a patent. in case that patent is not recommended in the patentability study, it will be protected by utility model. after protecting this result, the iags and devan will search insulation materials manufacturers will to acquire the license for a mass production of storepet.   
â¢ storepet final thermal insulation panel: we believe that this product cannot be protected under patent since the final panel is an integration of different materials: pet; pcm and fire retardant coating. for that reason, other modalities of protection will be analyzed such as utility model (protection for 10 years) or trade secret. the patentability study will provide the information required to make the best decision for its future commercialization.  
â¢ storepet simulation software "thermal building": we have checked that nowadays there aren't any commercialized or lab stage software able to allow engineers to choose the best pcm composition for each location and building features. for that reason, the consortium agreed on protecting this software under copyright for the exploitation in european market.   
  
main dissemination activities:  
â¢ start up and op-dating of the web page of the project: http://www.storepet-fp7.eu/   
â¢ preparation of diverse brochures and flyers presented in trade fairs, exhibitions and conferences related to building , advanced materials or textile industrial sectors.  
â¢ preparation of posters and communications in conferences and workshops.  
â¢ preparation of scientific papers, articles in specialized magazines and press releases.  
â¢ development and updating of a wikipedia article: http://en.wikipedia.org/wiki/the\_store-pet\_project   
â¢ organization and impart different workshops and training sectors for smes of the building sector as well as students of industrial engineering.   
â¢ participation in the following events: techtextil fair (11-13th january 2013, frankfurt /d); sejem dom (march 2013 ljubljana, slovenia); materiais 2013, conference materials science and engineering whatever the application (25th -27th march 2013 coimbra, portugal); aictc conference (31 th may 2013 dalmine, italy); proposte (6th-8th may 2013 como, italy); techtextil, international trade fair for technical textiles and nonwovens (11 th -13 th june 2013 fankfurt, germany); conference nanoitaltex 2013 (18 th october 2013 italy); a+a 2013, international trade fair for safety and health at work (5 th - 8 november 2013 dusseldorf, germany); conference sustainable building sb 2013 graz (25th â 28th september 2013 graz, austria); ispo 2014 (26th -29th january 2014 munich (d)); jec composites (12 â 14 march 2014 pais (f)); sejem dom (11 â 16 march 2014 ljubljana, slovenia); industrial technologies 2014 (9th - 11th april 2014 athens, greece); techtextil north america (13-15th may 2014 atlanta, usa); aittct conference (24-26th september 2014 shagnhai, china);   
list of websites:  
www.storepet-fp7.eu   
vladimir gumilar, construction cluster of slovenia, project coordinator, vladmir.gumilar@sgg.si  
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# PROCON

Project Acronym: PROCON

programme & topic: FP7-IDEAS-ERC ERC-SG-SH6

Most frequent returning words in objectives:

* ('textile', 17)
* ('production', 11)
* ('textiles', 9)
* ('project', 4)
* ('consumption', 4)
* ('mediterranean', 4)
* ('exchange', 4)
* ('analysis', 4)
* ('creation', 3)
* ('wealth', 3)
* ('europe', 3)
* ('period', 3)
* ('urbanisation', 3)
* ('research', 3)
* ('tools', 3)
* ('italy', 3)
* ('spain', 3)
* ('force', 2)
* ('economy', 2)
* ('urbanism', 2)
* ('evidence', 2)
* ('greece', 2)
* ('identification', 2)
* ('materials', 2)

the aim of the project procon is to test the hypothesis that textile production and consumption was a significant driving force of the economy and of the creation and perception of wealth in mediterranean europe during the period of urbanisation and early urbanism in 1000â500 bce. the project structure encompasses several research strands within the operational sequence of textile economy: resources, production, product, and consumption and exchange. the project analysed different categories of evidence (textiles, textile tools, art / visual representations, plant remains, and animal bones) from greece, italy, spain and surrounding countries, using a wide array of interdisciplinary methods.  
the use of scanning electron microscopy to analyse over 400 samples of archaeological textiles allowed identification of the raw materials used, which included flax and sheep wool across the region, with the addition of esparto in spain. liquid chromatography was used to identify plant-based dyes derived from woad and madder and, for the first time in italy, shellfish purple, that were used to add value to the cloth. structural analysis of the textile fragments permitted the definition of thread- and textile-making technologies, resulting in identification of distinct textile cultures in central-west and eastern mediterranean regions.  
functional and spatial analysis of almost 10,000 textile tools from 50 ancient settlements and sanctuaries permitted the definition of the organisational parameters of textile production, demonstrating that it was primarily household-based, although organisation varied between regions. burial evidence and quantitative analysis of iconographic data confirmed that primary producers of textiles were women.  
the diachronic iconographic analysis demonstrated the increased demand for and importance of clothing, as indicated by the exponential increase in quantity and quality of textile depictions over the period 1000â500 bce. demand for large quantities of sail cloth towards the end of the investigated period appears to be behind the switch from splicing to draft spinning flax yarn around 600 bce (identified in linen textiles), which allowed a more efficient and streamlined production process.  
exchange took place at multiple levels, including mobility of artisans (documented in the movement of textile tools), exchange of textiles (identified through textile imports), spread of specific technologies (e.g. the appearance of shellfish purple dyeing installations in spain only after the arrival of phoenician settlers). textile cultures appear to have spread with human migrations (e.g. from greece to south italy), leading to the creation of hybrid textile forms.  
the synthesis of the collected data demonstrates that textile production and consumption constituted a major economic factor during urbanisation of early iron age mediterranean europe. textiles served as a form of wealth which, like precious metals and exotica such as ivory and amber, underpinned the authority and power of the aristocracy.   
the communities of small and large urban centres of the early iron age required large quantities of textiles and were pressed to organise their consumption not only on the basis of local agro-pastoral activities but also through exchange activities. the transition from a ârural economyâ to âurban economyâ involved intensification of agricultural activity, including textile fibre production. the qualitative changes in textile production are reflected in the development of better raw materials, which allowed faster processing and production, as well as more complex techniques and patterns.  
taking developments in a specialist research field (textile archaeology) and applying them to modelling the dynamics behind the broader phenomenon of urbanisation in europe, the project fundamentally changed the trajectory of research and thinking about the ancient mediterranean, providing a position for textiles and textile production in the cultural and economic history of the past. in their role enabling wealth creation through enhanced quantity and quality in production, visualising political hierarchies through exclusive clothing marking social roles, and the impact of this on social relationships of production and politics, textiles were a powerful force of urbanism from 1000-500 bce.

# PROCON

Project Acronym: PROCON

programme & topic: FP7-IDEAS-ERC ERC-SG-SH6

Most frequent returning words in objectives:

* ('textile', 17)
* ('production', 11)
* ('textiles', 9)
* ('project', 4)
* ('consumption', 4)
* ('mediterranean', 4)
* ('exchange', 4)
* ('analysis', 4)
* ('creation', 3)
* ('wealth', 3)
* ('europe', 3)
* ('period', 3)
* ('urbanisation', 3)
* ('research', 3)
* ('tools', 3)
* ('italy', 3)
* ('spain', 3)
* ('force', 2)
* ('economy', 2)
* ('urbanism', 2)
* ('evidence', 2)
* ('greece', 2)
* ('identification', 2)
* ('materials', 2)

the aim of the project procon is to test the hypothesis that textile production and consumption was a significant driving force of the economy and of the creation and perception of wealth in mediterranean europe during the period of urbanisation and early urbanism in 1000â500 bce. the project structure encompasses several research strands within the operational sequence of textile economy: resources, production, product, and consumption and exchange. the project analysed different categories of evidence (textiles, textile tools, art / visual representations, plant remains, and animal bones) from greece, italy, spain and surrounding countries, using a wide array of interdisciplinary methods.  
the use of scanning electron microscopy to analyse over 400 samples of archaeological textiles allowed identification of the raw materials used, which included flax and sheep wool across the region, with the addition of esparto in spain. liquid chromatography was used to identify plant-based dyes derived from woad and madder and, for the first time in italy, shellfish purple, that were used to add value to the cloth. structural analysis of the textile fragments permitted the definition of thread- and textile-making technologies, resulting in identification of distinct textile cultures in central-west and eastern mediterranean regions.  
functional and spatial analysis of almost 10,000 textile tools from 50 ancient settlements and sanctuaries permitted the definition of the organisational parameters of textile production, demonstrating that it was primarily household-based, although organisation varied between regions. burial evidence and quantitative analysis of iconographic data confirmed that primary producers of textiles were women.  
the diachronic iconographic analysis demonstrated the increased demand for and importance of clothing, as indicated by the exponential increase in quantity and quality of textile depictions over the period 1000â500 bce. demand for large quantities of sail cloth towards the end of the investigated period appears to be behind the switch from splicing to draft spinning flax yarn around 600 bce (identified in linen textiles), which allowed a more efficient and streamlined production process.  
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# BRIGHT

Project Acronym: BRIGHT

programme & topic: FP7-JTI JTI-CS-2013-2-ECO-01-074

Most frequent returning words in objectives:

* ('bamboo', 76)
* ('fabric', 38)
* ('properties', 15)
* ('fibre', 15)
* ('project', 14)
* ('process', 14)
* ('bright', 12)
* ('impact', 12)
* ('fibres', 11)
* ('applications', 11)
* ('infinite', 11)
* ('glass', 11)
* ('development', 10)
* ('sandwich', 10)
* ('energy', 10)
* ('panels', 10)
* ('requirements', 10)
* ('species', 10)
* ('panel', 10)
* ('fibers', 10)
* ('production', 10)
* ('composites', 9)
* ('fabrics', 9)
* ('demonstrator', 9)

executive summary:  
bright was part of clean skyâs research and technology development projects. the call for proposal âapplication of bio materials based on bamboo fibres to cabin interior composite sandwich panelsâ aimed at developing technology demonstration, at a technology readiness level of 6, to enable bamboo to get closer to being used in aeronautic applications.  
  
this project targeted to develop an appropriate bamboo fabric for aeronautical applications. moreover, the process to extract bamboo and to transform it into fabric aims to be a low energy process. from bamboo fabric, another key challenge is to turn this fabric into composites (laminate and sandwich panels) suitable to be used for aircraft interiors. to valorise all the technologies developed within the project, a mid-cabin cabinet was to be manufactured and assembled.  
  
first of all, with inputs from the topic manager, a specifications document gathering all informations required to lead this project and to give all objectives to reach (mechanical properties, fire requirements or sustainability...) was produced.  
the first step was to select the most appropriate specie for aeronautical mid cabin applications. for that, auditions of bamboo cultivators were performed and a selection of several species answering requirements was done. technologies to extract fibres from raw bamboo and to manufacture infinite wire, were optimized in terms of energy consumption and product quality. weaving tests were also done using prototype infinite wires. a continuous process was analysed and established.  
a product life cycle assessment enabled to clearly demonstrate that bamboo fabrics using such infinite wires had improved environmental impacts compared to standard glass fibre fabrics.  
during the development of the bamboo fabric, studies to develop a bamboo composite matching the requirements were performed on a hand-made bamboo fabric. protocols to improve impregnation between bamboo fabric and epoxy resin and to enhance fire-retardant properties of bamboo fabric were set. mechanical and fire tests performed on bamboo composites (both laminate and sandwich panel) showed compliancy with specifications. a 3d model and fem model of demonstrator were made but due to a lack of time, the demonstrator was not manufactured.   
  
as a conclusion, bright has enabled to develop significant technology demonstration to answer most of the challenges but some tasks of interest remain unfinished and could be studied in the future as well as new topics of interest. these should include a methodology to get homogeneous, constant and reliable bamboo fibres (i.e batch to batch consistency regarding mechanical properties); an overall optimization of the process to get thinner bamboo infinite wires and fabrics (extraction step, weaving step...) and the development of a bamboo pre-preg.  
  
project context and objectives:  
natural fibers are rapidly emerging in composites applications where glass fibers have been traditionally used. these natural fibers provide several benefits: low cost, sustainable and abundant availability, lower densities, recyclability, biodegradability, competitive mechanical properties, and new functional characteristics.  
over the last decade, natural fibers have received increasing interest as a potential replacement for classical synthetic fibers and the aeronautical sector is extremely interested by all these advantages.  
bamboo represents an interesting resource of fibers for composite applications thanks to four essential parameters: mechanical properties, availability, low density (average density of 0.9), and rapid growth. bamboo fibers offer new perspectives for producing greener composites in the sense that they constitute a sustainable resource. in order to match with the needs of the aeronautical sector concerning mechanical characteristics of composites, bamboo fibers have to be extracted and transformed into a continuous thread and then be braided into a fabric that could be treated and impregnated with specific resins.  
the bright project will present an innovative low energy process for high quality bamboo fibers extraction, which conserves their intrinsic mechanical properties. the âinfinite bamboo wireâ resulting from this project will demonstrate its high performance for aeronautical composites applications. moreover, brightâs composite process innovates in reducing the number of steps to produce sandwich panel composites.  
  
the main objective of the bright project is to demonstrate the high mechanical properties of a bamboo fabric integrated in a sandwich panel as a green and efficient composite reinforcing textile meeting aeronautic constraints by:  
-developing a low energy process to transform bamboo into an appropriate fabric, preserving and optimizing the intrinsic mechanical properties of these exceptional bamboo fibers  
-demonstrating the high performances of a sandwich panel using our new composite in a mid-cabin demonstrator  
this main ambition can be divided into five main steps which will make the overall bright project realistic, measurable and successful within a 16-month time frame:   
1.identify which bamboo species is the best candidate for producing an aeronautic bamboo fiber-reinforced composite for interior sandwich panels based on mechanical properties / availability / ethical considerations.  
2. optimize the patented process producing a high performance âinfinite bamboo wireâ with consideration of:  
-low environmental impact  
-high conservation of bamboo specific mechanical properties meeting aeronautic specifications   
3. validate the fabric production and resin impregnation weaved with this infinite wire  
4. mould a composite using the bamboo fabric, previously developed, and characterize it in order to compare the results with glass fiber-reinforced composite performances and other natural fibre-reinforced composite performances  
5. manufacture a relevant âmid-cabin cabinetâ part of the demonstrator using our bamboo sandwich panel composite.  
project results:  
for the validation of one bamboo specie suitable for aeronautical constraints and applications, some bamboo suppliers were audited with respect to sustainable development and culture maturity criteria. the results show great potential with some significant issues to be resolved. these suppliers would enable significant improvements in terms of productsâ life cycle, as the distances between the bamboo plantations and production facilities would be optimized for a european manufacturer. four species were supplied and infinite wires were characterized in terms of ultimate tensile strengths. these results were compared with 5 other selected species from background data. the most appropriate specie was therefore selected for aeronautical mid-cabin cabinet applications.   
future research on species could reasonably be extended as there is over 1500 species.   
in order to have constant quality of extracted bamboo fibres, it is important to have a control on the way that bamboos grow. for that and similarly to what is currently developed for flax (celc), it is important to support (by an agro-industrial organization) ongoing developments in the different bamboo industries. several actions are necessary to improve state-of-the-art on the following subjects:   
- impact of soil geochemistry of use area as a function of selected bamboo specie.   
- impact of culm maturity on properties of bamboo fibres  
- a methodology on variability of properties of bamboo fabric with a tolerance as a function of field of application to ensure a final object meeting the requirements   
  
for the development of a bamboo fabric, thorough analyses and optimizations were performed on the main modules of fibre extraction, fibre assembly and wire winding.  
results enabled to produce prototype infinite wire with optimized fibres. the assessment of the fibre extraction facility concluded on the need to redesign it in order to increase fibre quality and productivity of strips, as well as to match the requirements (width, thickness,...).   
fibre assembly experimentations provided data and the limitations for different types of patented assembling technologies. analyses also showed the constraints of the assembling technology in terms of energy consumption and time-lapse for multiple bobbin manufacturing.   
wire winding tests brought out conclusions on the type of winding required for appropriate weaving.   
  
the produced bright prototype infinite wires were analysed and tested by weavers to manufacture several types of fabrics such as weaved, multi-axial and unidirectional. several limitations were identified which opened doors to new tests. for all types of fabrics, there is a good level of confidence to achieve fabric production in the close future. however, further testing still has to be performed in order to produce industrial bright bamboo fabrics, hence in large quantities to manufacture the demonstrator.  
  
analyses and developments were performed on the overall process in order to enable continuous manufacturing. an evolution of procedures enabled such a production. however, this continuous process and the weaving step should be further optimized to allow the production of infinite wire and bamboo fabric suitable for aeronautical application.  
  
productsâ life cycle assessments considered 16 indicators such as ozone depletion, human toxicity...the study came to the conclusion that for brightâs bamboo fabric, the most impacting variable was packaging with over 50% environmental impact on 44% indicators. transport was the second main contributor. relevant solutions were put forward to improve the overall environmental impact, such as the use of recycled or renewable materials for packaging instead of plastic based products. nevertheless, 15 indicators showed a significant improvement compared to a standard glass fibre fabric. only the land use indicator was slightly increased (1%).  
  
a focus was made on energy consumption for both the bamboo based fabric and a glass fibre fabric.  
the analyses, excluding packaging for better understanding of manufacturing processes, showed that brightâs bamboo fabric required 50% less energy consumption for its production compared with the glass fibre production even though capabilities are very different as glass is produced in enormous amounts. the explanation comes from the fact that glass fibre requires high temperatures to be produced.   
  
the life cycle assessment and the energy consumption studies were only performed up to the fabric due to lack of data, but this study should be completed to a composite level to have an overall view of savings.  
  
during the development of bright bamboo fabric, a fine analysis of state-of-the-art regarding treatments already presented in the literature to improve impregnation and fire-retardancy of natural fibres was done. from this research, several treatments were tried on a commercial bamboo fabric as well as combination of treatments to improve adhesion between bamboo fabric and the matrix. to define the best treatments, several analyses were performed on bamboo (microscopy, surface tension). the treatments were also looking through the environmental impact in terms of toxicity, recycling and energy consumption.  
sourcing of resins was done and appropriate ones, i.e. resins that can be used in aeronautical environments and in line with requirements were supplied. all resins were analysed. criterion of environmental impact was also taken into account to choose the resin.  
impregnation testing were performed in order to improve adhesion between fabric and matrix, surface aspect and to reduce porosity. several processes like pre-pregs, vacuum bag moulding and resin film infusion were considered. because of time and budget considerations, only some of them were tested and one process was approved. in the future, it would be interesting to study the development of pre-pregs of bamboo fabric since it is one of the processes widely used in aeronautical industry. the development and the use of fire-retardant bio-resin should also be interesting to study.  
  
to meet the requirements for aeronautical applications, composites should meet the standards for fire and mechanical tests.  
consequent works were performed to improve fire-resistance of bamboo fibres. indeed, natural fibres are more sensitive to fire than other fibres such as glass fibres. several treatments were tested. some of them promoted char formation that protect fabric from further burning. an optimal formulation was found and tested successfully. indeed, several bamboo laminates and panels met the fire requirements.  
bamboo panels and laminates were realized in order to characterize them.  
 a mechanical study was also conducted on laminates and panels and it was shown that bamboo fabric chosen was suitable for aeronautical cabin interiors applications. equivalent or better mechanical properties were obtained with bamboo panels compared to standard glass fibre panels used in aeronautics with the same panel weight.   
therefore, a protocol to produce bamboo-based composite panel was successfully set up. this bamboo sandwich panel exhibits remarkable properties that match the requirements for cabin interior environment. this panel provides an alternative solution to glass fibre sandwich panel. these technologies were not implemented onto brightâs bamboo fabric since the project ended before the manufacturing of sufficient amounts of bright bamboo fabric. future work would implement the technologies developed here to enhance impregnation and fire-retardant properties on bamboo fabric suitable for aeronautic mid-cabin applications. so, the demonstrator could be manufactured.  
  
however, regarding the demonstrator, a complete 3d, fem models and all manufacturing drawings of the mid-cabin cabinet were made. finish materials were approved and panelsâ panoplies were designed for cnc programming. moreover, several tests on bamboo panels showed that bamboo panels can be used for aircrafts interiors furniture. indeed, cutting process of bamboo panels with cnc (computer numeric control), edge filler application, pockets machining and assembling process with inserts were validated.  
  
  
potential impact:  
the impact of this project will be significant when commercialization of bamboo fabric and bamboo-based composite will take off. so far, the overall progress was made on single technologies (either on bamboo fibre/strip, infinite wire or bamboo fabric) and not fully implemented into a demonstrator. bamboo farming will also be developed but an effort has to be made on the development of bamboo industry to have reliable and consistent quality product especially for aeronautical usage. this effort has to be made at several levels starting from bamboo growth, its manufacturing into fabric up to the composite products. when the previous conditions will be met, bright project will enable to accelerate the development of the companies that took part in it, regarding employment for example.  
  
the main dissemination activities of this project were interviews by local press (paper, tv), publications on company website or publication in specialized press (composite).  
  
the study on bamboo species and the selection of bamboo species that fulfil technical requirements can be exploited to develop wires and fabrics from these species. some further testing is however still required as there is a significant number of species available on earth.  
the outputs of the study on fibre extraction tool, fibre assembly, multiple simultaneous fibre assembly and bobbin winding will be exploited and will help to redesign and finalized the production line of bamboo infinite wire.  
the results of energy consumption for the production of bamboo fabrics using technologies used and studied during bright show a positive impact that will be beneficial for dissemination.  
life cycle analysis (lca) of bamboo fabric have identified the key parameters (packaging) that impact results. proposed solutions will therefore enable to decrease the impact of future products.   
study of improvement of impregnation and fire-retardancy of bamboo fabric led to satisfactory results and exploitation of these results will lead to a patent of the protocols developed during bright project. further work would include the use of these protocols on optimized bamboo fabrics for the production of a demonstrator. future interesting works could also include the study of bamboo composites implementation with process close to those used in aeronautics, such as pre-pregs.  
  
list of websites:  
cobratex  
67 rue de la colombette  
31000 toulouse   
france  
  
edouard sherwood   
edouard.sherwood@cobratex.com   
+33 6 75 66 50 17  
  
veso concept (coordinator)  
1620 route de bellevue  
31530 mã©renvielle  
france  
www.veso-concept.com  
for further information, contact:  
mr david hardy (ceo veso-concept)  
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+33 534 575 490  
  
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11 faubourg bourbon  
32430 cologne  
france  
for further information, you can contact us at:  
info@kreative-engineering.com

# BRIGHT

Project Acronym: BRIGHT

programme & topic: FP7-JTI JTI-CS-2013-2-ECO-01-074

Most frequent returning words in objectives:

* ('bamboo', 76)
* ('fabric', 38)
* ('properties', 15)
* ('fibre', 15)
* ('project', 14)
* ('process', 14)
* ('bright', 12)
* ('impact', 12)
* ('fibres', 11)
* ('applications', 11)
* ('infinite', 11)
* ('glass', 11)
* ('development', 10)
* ('sandwich', 10)
* ('energy', 10)
* ('panels', 10)
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* ('composites', 9)
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executive summary:  
bright was part of clean skyâs research and technology development projects. the call for proposal âapplication of bio materials based on bamboo fibres to cabin interior composite sandwich panelsâ aimed at developing technology demonstration, at a technology readiness level of 6, to enable bamboo to get closer to being used in aeronautic applications.  
  
this project targeted to develop an appropriate bamboo fabric for aeronautical applications. moreover, the process to extract bamboo and to transform it into fabric aims to be a low energy process. from bamboo fabric, another key challenge is to turn this fabric into composites (laminate and sandwich panels) suitable to be used for aircraft interiors. to valorise all the technologies developed within the project, a mid-cabin cabinet was to be manufactured and assembled.  
  
first of all, with inputs from the topic manager, a specifications document gathering all informations required to lead this project and to give all objectives to reach (mechanical properties, fire requirements or sustainability...) was produced.  
the first step was to select the most appropriate specie for aeronautical mid cabin applications. for that, auditions of bamboo cultivators were performed and a selection of several species answering requirements was done. technologies to extract fibres from raw bamboo and to manufacture infinite wire, were optimized in terms of energy consumption and product quality. weaving tests were also done using prototype infinite wires. a continuous process was analysed and established.  
a product life cycle assessment enabled to clearly demonstrate that bamboo fabrics using such infinite wires had improved environmental impacts compared to standard glass fibre fabrics.  
during the development of the bamboo fabric, studies to develop a bamboo composite matching the requirements were performed on a hand-made bamboo fabric. protocols to improve impregnation between bamboo fabric and epoxy resin and to enhance fire-retardant properties of bamboo fabric were set. mechanical and fire tests performed on bamboo composites (both laminate and sandwich panel) showed compliancy with specifications. a 3d model and fem model of demonstrator were made but due to a lack of time, the demonstrator was not manufactured.   
  
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bamboo represents an interesting resource of fibers for composite applications thanks to four essential parameters: mechanical properties, availability, low density (average density of 0.9), and rapid growth. bamboo fibers offer new perspectives for producing greener composites in the sense that they constitute a sustainable resource. in order to match with the needs of the aeronautical sector concerning mechanical characteristics of composites, bamboo fibers have to be extracted and transformed into a continuous thread and then be braided into a fabric that could be treated and impregnated with specific resins.  
the bright project will present an innovative low energy process for high quality bamboo fibers extraction, which conserves their intrinsic mechanical properties. the âinfinite bamboo wireâ resulting from this project will demonstrate its high performance for aeronautical composites applications. moreover, brightâs composite process innovates in reducing the number of steps to produce sandwich panel composites.  
  
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-developing a low energy process to transform bamboo into an appropriate fabric, preserving and optimizing the intrinsic mechanical properties of these exceptional bamboo fibers  
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-low environmental impact  
-high conservation of bamboo specific mechanical properties meeting aeronautic specifications   
3. validate the fabric production and resin impregnation weaved with this infinite wire  
4. mould a composite using the bamboo fabric, previously developed, and characterize it in order to compare the results with glass fiber-reinforced composite performances and other natural fibre-reinforced composite performances  
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project results:  
for the validation of one bamboo specie suitable for aeronautical constraints and applications, some bamboo suppliers were audited with respect to sustainable development and culture maturity criteria. the results show great potential with some significant issues to be resolved. these suppliers would enable significant improvements in terms of productsâ life cycle, as the distances between the bamboo plantations and production facilities would be optimized for a european manufacturer. four species were supplied and infinite wires were characterized in terms of ultimate tensile strengths. these results were compared with 5 other selected species from background data. the most appropriate specie was therefore selected for aeronautical mid-cabin cabinet applications.   
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therefore, a protocol to produce bamboo-based composite panel was successfully set up. this bamboo sandwich panel exhibits remarkable properties that match the requirements for cabin interior environment. this panel provides an alternative solution to glass fibre sandwich panel. these technologies were not implemented onto brightâs bamboo fabric since the project ended before the manufacturing of sufficient amounts of bright bamboo fabric. future work would implement the technologies developed here to enhance impregnation and fire-retardant properties on bamboo fabric suitable for aeronautic mid-cabin applications. so, the demonstrator could be manufactured.  
  
however, regarding the demonstrator, a complete 3d, fem models and all manufacturing drawings of the mid-cabin cabinet were made. finish materials were approved and panelsâ panoplies were designed for cnc programming. moreover, several tests on bamboo panels showed that bamboo panels can be used for aircrafts interiors furniture. indeed, cutting process of bamboo panels with cnc (computer numeric control), edge filler application, pockets machining and assembling process with inserts were validated.  
  
  
potential impact:  
the impact of this project will be significant when commercialization of bamboo fabric and bamboo-based composite will take off. so far, the overall progress was made on single technologies (either on bamboo fibre/strip, infinite wire or bamboo fabric) and not fully implemented into a demonstrator. bamboo farming will also be developed but an effort has to be made on the development of bamboo industry to have reliable and consistent quality product especially for aeronautical usage. this effort has to be made at several levels starting from bamboo growth, its manufacturing into fabric up to the composite products. when the previous conditions will be met, bright project will enable to accelerate the development of the companies that took part in it, regarding employment for example.  
  
the main dissemination activities of this project were interviews by local press (paper, tv), publications on company website or publication in specialized press (composite).  
  
the study on bamboo species and the selection of bamboo species that fulfil technical requirements can be exploited to develop wires and fabrics from these species. some further testing is however still required as there is a significant number of species available on earth.  
the outputs of the study on fibre extraction tool, fibre assembly, multiple simultaneous fibre assembly and bobbin winding will be exploited and will help to redesign and finalized the production line of bamboo infinite wire.  
the results of energy consumption for the production of bamboo fabrics using technologies used and studied during bright show a positive impact that will be beneficial for dissemination.  
life cycle analysis (lca) of bamboo fabric have identified the key parameters (packaging) that impact results. proposed solutions will therefore enable to decrease the impact of future products.   
study of improvement of impregnation and fire-retardancy of bamboo fabric led to satisfactory results and exploitation of these results will lead to a patent of the protocols developed during bright project. further work would include the use of these protocols on optimized bamboo fabrics for the production of a demonstrator. future interesting works could also include the study of bamboo composites implementation with process close to those used in aeronautics, such as pre-pregs.  
  
list of websites:  
cobratex  
67 rue de la colombette  
31000 toulouse   
france  
  
edouard sherwood   
edouard.sherwood@cobratex.com   
+33 6 75 66 50 17  
  
veso concept (coordinator)  
1620 route de bellevue  
31530 mã©renvielle  
france  
www.veso-concept.com  
for further information, contact:  
mr david hardy (ceo veso-concept)  
david.hardy@veso-concept.com  
+33 534 575 490  
  
kreative engineering services (kes)  
11 faubourg bourbon  
32430 cologne  
france  
for further information, you can contact us at:  
info@kreative-engineering.com

# INTIMIRE

Project Acronym: INTIMIRE

programme & topic: FP7-SME SME-2

Most frequent returning words in objectives:

* ('fire', 50)
* ('retardant', 35)
* ('textile', 27)
* ('products', 18)
* ('properties', 18)
* ('fibres', 18)
* ('additives', 17)
* ('flame', 16)
* ('development', 14)
* ('fabrics', 13)
* ('formulation', 12)
* ('scale', 12)
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* ('materials', 11)
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* ('polyester', 11)
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executive summary:  
the objectives of intimire are connected with the evolution in the strict ce regulation and standard for fire retardant products:   
â¢ the regulations for materials used in railway transport: st en 45545   
â¢ the novel standards of upholstered furniture: norm nf d 60013   
â¢ the evolution of the automotive fire test standard fmvss 302.   
  
none of the textile products available today achieve the following points: the criteria of new norms, the environment preservation and the requirement of consumer (comfort, price, design ...).   
  
the present approaches in developing flame retardant upholstery fabrics is be no longer sufficient, when novel requirements need to be fulfilled such as:   
â¢ an exclusive use of fabrics with a low rate of heat release   
â¢ an avoidance of the use of fabrics that spread the fire to other elements with burning droplets.   
â¢ no release of toxic gaz.   
â¢ limitation at the minimum rate the smoke (the opacity of smoke threaten lifes during evacuation in case of fire).   
â¢ a use of fabrics that are capable to prevent ignition of the underneath layers (foam, or stuffing) even at intense flames (e.g. in railway application against vandalism using flames).  
  
the new material must have two main functions:  
â¢ fire retardant properties: increase the ignition time (not easy to ignite the materials).   
â¢ flame resistant properties: able to stop the propagation of flame, after ignition, and trap toxic gaz.   
currently, there is no textile product able in the same time, to achieve these two properties.  
the working principle lies in that expandable graphite will expand under high temperature and become char barriers which could reduce the air fluid and resist the fire effectively. furthermore, it will behave as active carbon to filter smoke when it is expanding.   
for these reasons, flame retardant expandable graphite has not only good performance in fire resistance but also low smoke, no dripping and no damage to human body and environment. these features could meet the future fire resistance tendency.   
  
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â¢ development of nano graphite as fire retardant additives. these additives have been incorporated in the thermoplastic resin, or back coating resin. in case of fire, the formulation is able to develop a carbon char in order to protect no burnt materials.  
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â¢ to develop a formulation able to promote an intumescent system in case of fire, at low rate for polyester. the main challenge is to disperse a low quantity of additives, homogeneously during the extrusion of fibre and to improve the mechanical properties of fibres.  
â¢ to find synergy agents able to improve the performance of standard additives in order to perform improved mechanical properties and to decrease the cost fibres.  
â¢ to process nano graphite in polyester fibre, in safe working conditions.  
â¢ to develop at pilot line intumescent fibres in order to realise non woven, woven, and knitting fabrics, able to be used for transport and home furniture applications.  
â¢ to promote intumescent textile support able to couple fire resistance properties and flame resistance properties. the ultimate goal is in case of fire hazard to develop a thermal insulating barrier able to protect the foam or element under the textile support.  
â¢ to promote 3 types of demonstrators: elements for filters, railwaysâ textile seat and upholstery chair.  
â¢ to validate the performances of new materials according to new european standard.  
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industrial requirements have been set up first, and intumescent fire retardant formulation for pet and pp polymer at laboratory scale were performed. the main objectives were:  
â¢ to characterise physically and chemically the raw material thanks to normalised methods.  
â¢ to characterise the mechanism of thermal degradation and fire behaviour under approached conditions of fire (irradiance in the range of 30 kw/mâ²).  
â¢ to select additives able to promote intumescent phenomena for polypropylene and for polyester  
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â¢ to produce at laboratory scale synthetic fibres able to promote a carbon char in case of fire, based on polypropylene or polyester matrix  
â¢ to characterise the fire behaviour and thermal degradation of manufactured products.  
â¢ to provide knowledge basis for the processing routes for the charged polymer, in order to scale up to industrial feasible production processes  
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â¢ to define the appropriate processing routes to prepare textile support from fibres manufactured   
â¢ to study the impact of structure and composition of textiles on the fire behaviour and heat resistance  
â¢ to develop integrated finishing process according to the need of end user  
2 ways to produce textile structures were investigated: knitted and nonwoven. 8 knitted structures were obtained, and 1 nonwoven structure.  
  
flame-retardant coatings were developed based on acrylic and polyurethane binders, and applied on textile structures.  
  
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- quantity of additives to achieve fire retardant properties   
- difficulty to incorporate the additive in polymer matrix (temperature of degradation of polymer matrix, quality of dispersion, avoid the agglomerates)  
- difficulty to spin the fibres including the charges (management of viscosity of treated polymer, couple fire retardant properties and mechanical properties)  
  
alternatives plan in order to achieve fire retardant fibres based on intumescent fibres could be:   
- test different formulations to promote carbone char based on graphite, phosphorus component.  
- associate synergy agent (cost, compatibility with matrix and other additives, difficulty to spin the formulation.  
- development of additives with a small diameter.  
- development of microencaspulatives formulation.  
- development of back coating or hot melt.  
  
the advantages of intumescent system remains the following:  
- halogen free   
- no toxic gas in case of fire   
- formation of carbon char able to protect other material   
- low impacts on environment   
the limits today of intumescent system for textiles application are the quantity of additives to reach the fire retardant properties, and the spinability of formulations.  
  
  
potential impact:  
the demand for products in home textiles, fluctuates broadly in line with the economic cycle (real incomes, unemployment levels, interest rates, etc). this cyclicality, in the case of home textile end products demand (such as beds, upholstered furniture and carpets) is more highly variable than most other end-use segments, where purchase does not represent such a major investment for the consumer (e.g. waterproof coats), replacement cannot be easily postponed (e.g. car tyres, protective clothing) or where demand is less closely related to the economic cycle (e.g. medical products).  
  
a positive influence on the demand for hometech end products relates to trends in contract applications, where the demand is closely linked with the level of activity in the more general levels of infrastructure development, construction and capital spending (e.g. new and refurbished offices, hospitals, and hotels).  
  
the markets for most traditional products such as carpets, furnishing fabrics and mattresses are fairly mature in western economies. however, over recent years, as result of more stringent fr regulations in the major developed markets flame retardant textiles have increased their share.  
  
share of flame retardant textiles  
curtains 8 %  
drapes 20 %  
upholstery fabrics 39 %  
blankets 5 %  
bedspreads 5 %  
bedding 2 %  
mattresses thicking 2 %  
  
concerning textile for transport : today the transportation sector represents the single most valuable world market for technical textiles  
in this scenario, as economic expansion is generating demand for a better system of transport and rail freight continues to account for a small percentage of inland goods traffic, cars and other commercial vehicles will be used in increasing numbers. if the demand for cars is heavily dependent on real personal income, the demand for commercial and public service vehicles is more closely correlated with economic and population growth and the increased need to move people and goods.   
moreover as the private car will be priced out of many city centres and the work journeys will continue to grow, the provision of increasingly sophisticated and efficient public transport solutions will increase worldwide. international trade will need larger volumes of goods and huge number of people to be transported with the additional demand for larger, faster and more economical ships and aircraft.  
  
passenger car applications still largely dominate the transport sector, setting the pace for engineered textile products and high quality in volume markets.  
  
in passenger cars textile products range from lightweight nonwovens used in filters through, a variety of interior trim (woven and nonwoven), tufted or needlepunched carpets, seat fabrics of various types.  
  
in commercial vehicles, furnishing textiles generally play a less important role in commercial vehicles compared with passenger cars. however, the technical requirements of textiles in many end-uses are even more critical and demanding because of the heavier use to which they are continually subjected.   
performance furnishing materials play a more essential role in public service vehicles(buses, coaches, trams and trains) where they must provide high levels of durability and safety (particularly fire retardancy) as well as good aesthetic appeal.   
  
in car textiles market there is a huge range in the amount of textiles used in motor vehicles with different required methods of evaluation and standards of performance  
  
  
the impact of the intimire project outcomes for the partners are the following:  
â¢ development of new range of products more environmentally friendly, simplier and cost effective solutions  
â¢ creation of network to find new customers and create a high level knowledge about the fire behaviour characterisation  
â¢ development of fire retardant structure through the members of ivgt  
â¢ identification of the needs of some end users  
â¢ creation of dynamic networking for advanced textiles materials  
â¢ development of lightweight structures based on textile with improved thermal resistance and fire retardant properties  
â¢ new products based on fire retardant properties (advantages)  
â¢ synergies among all those operating in this field   
â¢ contacts with institutions, customers and potential users in europe and abroad as well as with european and international associations and key authorities (cen, euratex, ifai)   
â¢ promotion through participation to fairs in europe and abroad, conferences, press   
â¢ development of fire retardant materials for textile applications  
â¢ optimisation of process for dispersion  
â¢ network built-up: fire retardant additives producers and textile companies   
â¢ increase the knowledge of its members about the fire retardant additives and legislation  
â¢ scale up of production of textile across several members  
â¢ organisation of international technological day  
â¢ reinforce the links between smeâs and rtd performers  
â¢ creation of network  
â¢ protocol adapted to the textile structures  
â¢ formulation based on biosourced additives  
â¢ development of ecofriendly treatment for polypropylene fibres based on microencapsulated products  
â¢ creation of networking about fire retardant additives and advanced textile materials   
  
list of websites:  
http://intimire.ensait.fr/

# INTIMIRE

Project Acronym: INTIMIRE

programme & topic: FP7-SME SME-2

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- difficulty to spin the fibres including the charges (management of viscosity of treated polymer, couple fire retardant properties and mechanical properties)  
  
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- test different formulations to promote carbone char based on graphite, phosphorus component.  
- associate synergy agent (cost, compatibility with matrix and other additives, difficulty to spin the formulation.  
- development of additives with a small diameter.  
- development of microencaspulatives formulation.  
- development of back coating or hot melt.  
  
the advantages of intumescent system remains the following:  
- halogen free   
- no toxic gas in case of fire   
- formation of carbon char able to protect other material   
- low impacts on environment   
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a positive influence on the demand for hometech end products relates to trends in contract applications, where the demand is closely linked with the level of activity in the more general levels of infrastructure development, construction and capital spending (e.g. new and refurbished offices, hospitals, and hotels).  
  
the markets for most traditional products such as carpets, furnishing fabrics and mattresses are fairly mature in western economies. however, over recent years, as result of more stringent fr regulations in the major developed markets flame retardant textiles have increased their share.  
  
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in this scenario, as economic expansion is generating demand for a better system of transport and rail freight continues to account for a small percentage of inland goods traffic, cars and other commercial vehicles will be used in increasing numbers. if the demand for cars is heavily dependent on real personal income, the demand for commercial and public service vehicles is more closely correlated with economic and population growth and the increased need to move people and goods.   
moreover as the private car will be priced out of many city centres and the work journeys will continue to grow, the provision of increasingly sophisticated and efficient public transport solutions will increase worldwide. international trade will need larger volumes of goods and huge number of people to be transported with the additional demand for larger, faster and more economical ships and aircraft.  
  
passenger car applications still largely dominate the transport sector, setting the pace for engineered textile products and high quality in volume markets.  
  
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performance furnishing materials play a more essential role in public service vehicles(buses, coaches, trams and trains) where they must provide high levels of durability and safety (particularly fire retardancy) as well as good aesthetic appeal.   
  
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â¢ development of new range of products more environmentally friendly, simplier and cost effective solutions  
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â¢ promotion through participation to fairs in europe and abroad, conferences, press   
â¢ development of fire retardant materials for textile applications  
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â¢ protocol adapted to the textile structures  
â¢ formulation based on biosourced additives  
â¢ development of ecofriendly treatment for polypropylene fibres based on microencapsulated products  
â¢ creation of networking about fire retardant additives and advanced textile materials   
  
list of websites:  
http://intimire.ensait.fr/

# INTIMIRE

Project Acronym: INTIMIRE

programme & topic: FP7-SME SME-2

Most frequent returning words in objectives:

* ('fire', 50)
* ('retardant', 35)
* ('textile', 27)
* ('products', 18)
* ('properties', 18)
* ('fibres', 18)
* ('additives', 17)
* ('flame', 16)
* ('development', 14)
* ('fabrics', 13)
* ('formulation', 12)
* ('scale', 12)
* ('intumescent', 12)
* ('materials', 11)
* ('behaviour', 11)
* ('polyester', 11)
* ('textiles', 11)
* ('demand', 9)
* ('requirements', 8)
* ('case', 8)
* ('ignition', 8)
* ('order', 8)
* ('polypropylene', 8)
* ('thermal', 8)

executive summary:  
the objectives of intimire are connected with the evolution in the strict ce regulation and standard for fire retardant products:   
â¢ the regulations for materials used in railway transport: st en 45545   
â¢ the novel standards of upholstered furniture: norm nf d 60013   
â¢ the evolution of the automotive fire test standard fmvss 302.   
  
none of the textile products available today achieve the following points: the criteria of new norms, the environment preservation and the requirement of consumer (comfort, price, design ...).   
  
the present approaches in developing flame retardant upholstery fabrics is be no longer sufficient, when novel requirements need to be fulfilled such as:   
â¢ an exclusive use of fabrics with a low rate of heat release   
â¢ an avoidance of the use of fabrics that spread the fire to other elements with burning droplets.   
â¢ no release of toxic gaz.   
â¢ limitation at the minimum rate the smoke (the opacity of smoke threaten lifes during evacuation in case of fire).   
â¢ a use of fabrics that are capable to prevent ignition of the underneath layers (foam, or stuffing) even at intense flames (e.g. in railway application against vandalism using flames).  
  
the new material must have two main functions:  
â¢ fire retardant properties: increase the ignition time (not easy to ignite the materials).   
â¢ flame resistant properties: able to stop the propagation of flame, after ignition, and trap toxic gaz.   
currently, there is no textile product able in the same time, to achieve these two properties.  
the working principle lies in that expandable graphite will expand under high temperature and become char barriers which could reduce the air fluid and resist the fire effectively. furthermore, it will behave as active carbon to filter smoke when it is expanding.   
for these reasons, flame retardant expandable graphite has not only good performance in fire resistance but also low smoke, no dripping and no damage to human body and environment. these features could meet the future fire resistance tendency.   
  
the achievements of the project are:  
â¢ development of nano graphite as fire retardant additives. these additives have been incorporated in the thermoplastic resin, or back coating resin. in case of fire, the formulation is able to develop a carbon char in order to protect no burnt materials.  
â¢ development of rdt activities to optimize the fire retardant behaviour of polyester and polypropylene with formulation totally free of halogen. the behaviour of each formulation has been analyzed. the criteria of selection of formulation are based on the ignition time rate of heat release and quantity of smoke released during the combustion.  
â¢ the tests of spinability have been undertaken for the most performing formulation pet and pp. it is possible to produce multifilament pp on a semi-industrial scale with 10 wt-10% of the retardant ya whatever the amount of fire retardant ya, a very small decrease in tenacity was noticed whereas the strain at the break decrease with increasing concentration. the fibres produced have developed a low volume of char. some formulation based on additive ya and synergistic agents seem to give more encouraging results.  
â¢ some additives are focused on the microencapsultation of fr additives. the microencapsulation of additives is a success. multifilament yarns filled with the microcapsules containing fr were produced and mechanical properties were evaluated. all the formulations selected with the microcapsulated products failed for passing the din 4102 (vertical test). the protocol of washing microcapsules has an impact on the performance.  
â¢ some rdt activities have been investigated with the hot melt process.  
â¢ in order to optimize the fire retardant behaviour of samples, a back coating able to produce carbon expandable char have been evaluated. the application of fire retardant back coating involves a decrease of heat release.  
  
association of smeâs has organised dissemination and training session in order to identify the requirements for the transport market and invites their members to create a network with the intimire consortium.  
formulations have been scales up to semi industrial scale. however, optimisation is still needed to perform an acceptable industrial production. the ultimate goal is to scale up the selected formulation at the semi-industrial scale and industrial scale. this type of fibres shoes does not exist on the market. the final intumescent structure based on blend of yarns (intumescent or not), or based on fire retardant coating should answer to the new requirements of norms for public places, transports (example: cen 45-554 for railways applications).  
project context and objectives:  
the intimire project targets the production of new fire retardant and flame resistant polyester (pet) and polypropylene (pp) fibres, films and upholstery end products based on the original intumescent flame retardancy concept. these products will offer a technical solution to the evolution in requirements defined in upcoming european norms for upholstered furniture and railway transportation. they also must offer improved durability and thermomechanical properties.  
  
intimireâs first motivation is to address specific problems faced by european smes textile industries. they are connected with the evolution in the strict ec regulations and standards for fire retardant products:  
â¢ the regulations for materials used in railway transportation: st en 45545  
â¢ the novel standards of upholstered furniture: norm nf d 60-13  
  
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â¢ an exclusive use of fabrics with a low rate of heat release   
â¢ an avoidance of the use of fabrics that spread the fire to other elements with burning droplets.  
â¢ a use of fabrics able to prevent ignition of the underneath layers (foam, or stuffing) even at intense flames (e.g. in railway application against vandalism using flames).  
  
in order to achieve the criteria of the new standards, it is mandatory for upholstery fabrics to offer a much higher level of fire protection than what had to be fulfilled up to now. the standard flame retardant polyester fibres and certainly the existing flame retardant pp fibres (using halogen based flame retardants) will not be able to fulfil all these requirements.   
  
it is very important to notice that the fire behaviour of complete materials (complex made of foams + textile covering) have no relation with the fire behaviour of component, if taken individually. for example, the following figure present the rate of heat release of polyurethane foam, the one of fire retardant textile polyester structure and the one of the two elements bounded. it is clear that textile structure is not able to protect the foam, as the curve of the complex tends to be similar to the foam to be protected.   
  
even the flame retardant back-coatings used today need to be dramatically improved to prevent the ignition of the foam underneath the fabric . the new material must have two main functions:  
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currently, there is no textile product able in the same time, to achieve these two properties.   
  
the objectives of intimire are :  
â¢ to develop a formulation able to promote an intumescent system in case of fire, at low rate for polyester. the main challenge is to disperse a low quantity of additives, homogeneously during the extrusion of fibre and to improve the mechanical properties of fibres.  
â¢ to find synergy agents able to improve the performance of standard additives in order to perform improved mechanical properties and to decrease the cost fibres.  
â¢ to process nano graphite in polyester fibre, in safe working conditions.  
â¢ to develop at pilot line intumescent fibres in order to realise non woven, woven, and knitting fabrics, able to be used for transport and home furniture applications.  
â¢ to promote intumescent textile support able to couple fire resistance properties and flame resistance properties. the ultimate goal is in case of fire hazard to develop a thermal insulating barrier able to protect the foam or element under the textile support.  
â¢ to promote 3 types of demonstrators: elements for filters, railwaysâ textile seat and upholstery chair.  
â¢ to validate the performances of new materials according to new european standard.  
project results:  
industrial requirements have been set up first, and intumescent fire retardant formulation for pet and pp polymer at laboratory scale were performed. the main objectives were:  
â¢ to characterise physically and chemically the raw material thanks to normalised methods.  
â¢ to characterise the mechanism of thermal degradation and fire behaviour under approached conditions of fire (irradiance in the range of 30 kw/mâ²).  
â¢ to select additives able to promote intumescent phenomena for polypropylene and for polyester  
â¢ to develop fire retardant masterbatch for polyester and for polypropylene at laboratory and pilot scale  
â¢ to characterise the fire behaviour and the thermal degradation of treated masterbatch  
  
the project allowed to obtain characterization and fire retardant methods:  
  
concerning thermal degradation analysis (thermogravimetric analysis (tga)), this method can be used to evaluate the thermal stability of the basic components (additives and polymers) and produced blends.  
concerning fire behaviour characterization, depending on the final application and the existing standards, a lot of tests exist to which the material could be submitted.  
in a first step, two discriminative and interesting tests were used:  
â cone calorimeter test (iso 5660-1 used for railways applications)  
â smoke chamber test (iso 5659-2 used for railways applications)  
â horizontal flammability test (fmvss 302)  
  
the main objectives of the development of intumescent fibres based on polypropylene and polyester were:  
â¢ to produce at laboratory scale synthetic fibres able to promote a carbon char in case of fire, based on polypropylene or polyester matrix  
â¢ to characterise the fire behaviour and thermal degradation of manufactured products.  
â¢ to provide knowledge basis for the processing routes for the charged polymer, in order to scale up to industrial feasible production processes  
the main results obtained is the development of fibers at different scales. spinability was evaluated at laboratory scale, fibers were evaluated at the semi-industrial scale. 8 formulations lead to the production of fibres, from few grams to 1 kilogram. 6 formulations were based on polypropylene, 2 formulations were based on polyester.  
  
based on the fibres obtained, it was targete a development of high added value textile structures able to promote thermal insulation barrier in case of hazard. the main objectives were:  
â¢ to define the appropriate processing routes to prepare textile support from fibres manufactured   
â¢ to study the impact of structure and composition of textiles on the fire behaviour and heat resistance  
â¢ to develop integrated finishing process according to the need of end user  
2 ways to produce textile structures were investigated: knitted and nonwoven. 8 knitted structures were obtained, and 1 nonwoven structure.  
  
flame-retardant coatings were developed based on acrylic and polyurethane binders, and applied on textile structures.  
  
the textile structures (either with fr fibres, either with fr coating) were tested. however, the results returns in a general ways with low performances, with sometimes no improvement from the fr additive comparing the non fr textile structure and the fr one. the bottlenecks are the following:  
- quantity of additives to achieve fire retardant properties   
- difficulty to incorporate the additive in polymer matrix (temperature of degradation of polymer matrix, quality of dispersion, avoid the agglomerates)  
- difficulty to spin the fibres including the charges (management of viscosity of treated polymer, couple fire retardant properties and mechanical properties)  
  
alternatives plan in order to achieve fire retardant fibres based on intumescent fibres could be:   
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list of websites:  
http://intimire.ensait.fr/

# missing

Project Acronym: missing

programme & topic: missing missing

Most frequent returning words in objectives:

* ('newspec', 37)
* ('precursor', 33)
* ('carbon', 32)
* ('fibres', 28)
* ('process', 27)
* ('stabilization', 23)
* ('equipment', 21)
* ('pilot', 17)
* ('project', 15)
* ('treatment', 15)
* ('phase', 15)
* ('pe-cfs', 15)
* ('fibre', 15)
* ('temperature', 15)
* ('fiber', 15)
* ('manufacturing', 14)
* ('line', 13)
* ('production', 12)
* ('endless', 12)
* ('raman', 12)
* ('work', 12)
* ('carbonization', 12)
* ('samples', 12)
* ('hdpe', 11)

executive summary:  
carbon fibres (cfs) are the most efficient reinforcing materials in modern composite applications that require high specific stiffness and strength. in this context, the development of cheaper and more sustainable fibres is nowadays of paramount importance and this is further exacerbated by the current high demand for cfs.  
newspec was aimed at the production of low cost cfs through very promising polyethylene (pe) precursor. pe, as precursor, has very much interesting technical features but it presents also several technological challenges that are not yet solved by state-of-art solutions. therefore, newspec was proposing some crucial r&d breakthrough which are associated to high impacts as well as high risks.  
newspec has generated in total 74 accepted deliverables with 15 achieved milestones. the project ends with 2 published international patents, one related to the innovative process for solid-phase sulfurization of pe precursor and one related to plasma surface treatment process, as well as a number of high level publications and conference presentations.  
besides dissemination, newspec organized two very successful training courses for young students and engineers that provided a unique opportunity to put in contact the academic sector and the carbon composite industry, thus offering to young people both a high level formation and a qualifying experience.  
during newspec some innovative and working prototype machines for continuous endless cfs processing have been designed, developed and tested, in particular: a melt-spinning process equipment capable of semi-industrial manufacturing of pe fibres, the gas phase sulfurization equipment (called âsulfiâ), a double-spot plasma equipment for cf surface functionalization and a remote raman probe for in-line monitoring of mechanical features of the produced cfs.  
the project has generated fundamental know-how related to low-cost cfs manufacturing from innovative precursors, such as polyethylene. before newspec, many unknowns were present in the chemistry of pe material and several risks related to its handling were not yet well defined. newspec made a big step forward in this direction: during the project a huge number of compounds were tested, many diverse solutions were tried and lot of attempts were done. many of them failed, but all those failures helped us to find the right direction for a new pe-cfs manufacturing path.  
finally, newspec ends with a relevant number of exploitable results which are not only interesting for carbon fibre manufacturing industry but also to other stakeholders such as advanced polymer makers, textile producers, plastic compounds suppliers, machines manufacturers and various end-users of the carbon composite material chain.  
in conclusion, newspec project has put good and strong basis on which to build up a new way of manufacturing low-cost pe carbon fibres. the perspective of this consortium is to finalized the experimental work at pilot level scale in order to definitively prove the industrial feasibility of our idea. once this will be done, it will be necessary to aggregate investments for a process scale-up to a pre-industrial manufacturing line with a limited production capacity (e.g. some tons per year), that will be necessary to fully evaluate the technical and economic viability of this technology.  
project context and objectives:  
carbon fibres (cfs) are the most efficient reinforcing materials in modern composite applications that require high specific stiffness and strength. a steady increase in future production and consumption of cf is predicted due to increasing demand from classical and new industrial segments such as aerospace, automotive, wind energy, sport goods and other industrial applications such as high pressure gas storage. however, the extensive use of cfs in large volume market applications is severely limited by the current market price of cfs - over 20 euro/kg - that results from the dependence on petroleum-based precursors and the laborious, expensive and often non-environmental friendly conversion processes.  
  
in this context, the development of cheaper and more sustainable fibres is indeed nowadays of paramount importance and this is further exacerbated by the current high demand for cfs.  
  
newspec was aimed at the production of cfs through very promising precursors, such as polyethylene (pe). pe presents interesting technical features like high carbon yield (around 70%), high processability, flexibility and very competitive cost (~2 euro/kg) with respect to pan precursor that may result into a precursor cost saving of up to 70%.  
the target technical features of the pe-cfs should be: 250 gpa tensile modulus, 2 gpa tensile strength, 1% elongation, 10 microns diameter, and 1.8 g/cm3 density. the resulting cfs must be also homogenous with very smooth fibre surfaces (low surface roughness) and residual sulphur content as low as 1%wt (or even less upon optimization of carbonization time and temperature).  
considering the overall cf production cycle, the estimated final target cost of pe-cfs was expected to be around 10 euro/kg, which means a cost reduction of 30% with respect to comparable pan based fibres. to prove overall environmental and economic sustainability, specific lca and lcc have been implemented within all phases of the project.  
  
main breakthroughs proposed by the newspec project were:  
1. optimized ldpe and hdpe fine fibres processed by melt-spinning (instead of conventional wet spinning) which has been never attempted so far. besides, bio-pe precursor was used. bio-pe derives from dehydration of bio-ethanol to ethylene and then polymerization to pe and this precursor offers significant advantages:  
a. bio-ethanol is largely available today - its production has rated 100 bln litres in 2011 (eocd-fao) â being mostly produced as a fermentation by-product of sugarcane and other annual food crops (corn, wheat, barely).  
b. bio-pe exhibits the same chemical and physical properties as pe from fossil resources and good purity;  
c. its energy consumption in the cycle (biomass to polymerization) is reduced by about 70% when compared to the petrochemical cycle;  
d. is a sustainable, renewable and ecological precursor: producing 1kg of bio-pe captures 2.5 kg of co2 from the atmosphere.  
a major challenge was not only to spin fine continuous fibres (up to 12k tows) but also to make them compatible with subsequent stabilization and carbonization steps.  
  
2. for pe stabilisation an original sulphur vapour phase stabilization method assisted by electron beam curing (ebc) that introduces heteroatoms at the precursor stage has been proposed. the sulfuration leads to thiopolymers, which can condense to polyaromatic systems very similar to pan. the new approach has technical, economic and ecologic advantages thus ensuring very innovative and flexible development of new cfs.  
however, this required the development of a radically new equipment for continuous fibres treatment which represents the main technical challenge of newspec project.  
a main attribute of this project is the use of an available high performance fibre centre (hpfc) pilot scale facility that allows design and optimization of endless cf processing and easy scale up to a larger size industrial plant.  
  
3. novel strategies for the reduction of the graphitisation temperature via the use of nucleation agents such as cellulose nanowhiskers (cnws), cnts, graphite powders or graphene oxide (go) have been envisaged. lowering the graphitization temperature from 1500â° to 1200â°c can contribute to cost reduction of about 15-20% with respect to typical pan process. we were also expecting that the nps provide increased mechanical properties of fibres thus contributing to facilitate the pe sulphorization step.  
  
4. the partners explored the possibility of cfs surface modification. surface functionalisation is a necessary ingredient for the efficient use of cfs since the strength of the interface governs the properties of the resulting composite materials. within newspec, several innovative functionalization routes for the surface treatment of pe-based cf have been explored: (a) atmospheric plasma technology for controlled oxidation and grafting of other selected functional groups to the surface; (b) new methods of rapid room-temperature grafting on graphitic surfaces using specific surface-attacking chemicals. these new approaches were confronted with conventional electrochemical treatment. successful replacement of conventional methods by either (a) or (b) will further reduce the overall cost of the fibre and make the whole fibre process more sustainable.  
the structure of the new cfs had to be characterised with various spectroscopic methods and structure-to-property models have been developed. the efficiency of the various treatments shall be also assessed with specific techniques. surface techniques like xps are employed to identify the implanted chemical species. furthermore, pertinent analytical treatments based on shear-lag analysis (for polymer composites) are employed to assess the transfer length for efficient reinforcement and the interfacial shear strength of these systems.  
  
5. one of the newspec objectives was to develop and optimize one transportable confocal micro raman system which has to be used on the processing line for monitoring the various steps of cf synthesis.  
an automated system was developed and installed in the hpcf pilot line and it is capable for acquiring spectra from different locations of the production line. the proposed system offers significant capabilities for a non-destructive quality assessment in the fibre production line. parameters such as the degree of crystallinity, carbonization and graphitization of cfs, the level of disorder and structural information will be provided in-situ.  
  
carbon composite coupons and prototypes have been manufactured and tested by the end-users during the lifetime of the project to ensure the validation of cf functionality for the final components with this ensuring proper exploitation of results.  
newspec has involved specialized end-users as manufacturer of carbon composites, both cf reinforced and carbon ceramic matrix composites, in each of above mentioned segments: aerospace, automotive, wind, oil/gas transportation and storage. those sectors were identified as some of the most promising either in terms of pe-cfs technical requirements and in order to maximize the impact of the project results.  
project results:  
overview  
the newspec programme has run for 54 months (48 months of the original workplan plus a 6 months prorogation) and the activities were split down in the following work packages:  
as outputs, newspec has generated in total 74 accepted deliverables with 15 achieved milestones.  
many of the original objectives have been successfully met, all except that the foreseen validation and functional demonstration of pe-cfs in real industrial environment. this work has been not possible due to the fact that the project produced only a few hundred grams of pe-cfs which were not optimized for making big size industrial samples, thus the corresponding wp7 has been cancelled from the work programme.  
nevertheless, newspec ended with 2 published patents and a number of high level publications and conference presentations. moreover, in the framework of newspec some innovative prototype equipment that will be described in detail in the following sections have been designed, developed and tested, namely:   
i) melt-spinning equipment for semi-industrial manufacturing of pe fibres at ditf,  
ii) the gas phase sulfurization equipment by dienes (called âsulfiâ),   
iii) the remote raman probe by forth, and   
iv) the double-spot plasma equipment by vito.  
the development, validation and assessment of the pe-cfs has been thought according to three phases that correspond, to related technical wps:  
1. lab phase i.e. establishment of pe-cfs processing at batch level (wp2);  
2. pilot phase i.e. upscaling of endless carbon fibre manufacturing at hpfc (wp3);  
3. demo phase i.e. manufacturing of cf reinforced composites and material coupons (wp6);  
the newspec programme started at relatively low trl. thus, a remarkable amount of work and effort was necessary to investigate the pe-cfs manufacturing on batch (stationary) process (wp2). this work included several issues such as: a) precursor preparation, b) optimization of the parameters for melt spinning, c) precursor stabilization (cross-linking) and d) carbonization (best temperature profiles and treatment times in stabilization for high carbon yields and good mechanical properties of carbon fibres).  
the work done in wp2 and its deliverables have paved the way for upscaling the cfs manufacturing to a continuous process (endless fibres) having well defined all required process steps, methods and parameters. after completion of batch processing phase of pe-cfs, the newspec programme run into endless cfs manufacturing at hpfc pilot facility in denkendorf (de).  
for the manufacturing of endless pe-cf it has been necessary to complete the existing hpfc pilot line with specific equipment for pe precursor handling and stabilization. in fact, newspec aims to replace the wet (acidic) oxidation employed so far for pe stabilization with a dry method that introduces heteroatoms at the precursor stage and a combination thereof with electron beam curing (ebc) for pe cross-linking. this process was radically innovative and never attempted so far to stabilize endless pe fibres on a pilot scale level.  
during newspec, dienes was in charge to design and install the equipment for the sulphur gas-phase stabilization of the cross-linked pe-precursor. this has been a challenging activity, since there was no previous research experience and many technical unknowns were behind the corner. nevertheless, thanks to restless commitment of diened and ditf, the equipment, called âsulfiâ, has been installed at hpfc in april 2016 and begun to be operational in september 2016. this equipment has to fulfil the machinery directive 2006/42/ec en 60204-1: 2007 (safety of machinery - electrical equipment of machines) and an independent technical audit was performed by tuv in august 2016 to ensure that the facility could operate without any safety risk.  
wp6 aimed at the validation of newly developed fibres for composite manufacturing in selected industrial segments. some composites coupons were designed, produced and characterized by astm standard tests. however, due to the delay with operation of the pilot stabilization equipment and little availability of pe-cfs materials for the end-users, at the end it was possible to realize only very small samples size. in parallel, the end-users carried on activities of preparation of reference materials either using pan type or other similar cfs. this can be used as a first test to evaluate and compare in the future the performance of the products made with the new pe fibres with those made with commercial one. moreover, these tests can be useful to set up the prototype production process whenever pe-cfs will be available.  
aside to these activities two crucial wps were related to the development of alternative surface treatments (like plasma and rt epoxidation) and to non-destructive structural and mechanical characterisation of fibres by implementing real-time in-line tools (remote raman probe). both wps were completed with success.  
in the following sections we will present the main technological achievements of newspec. for obvious reasons related to the exploitation of the ip, some fine details are kept undisclosed.  
  
bio-pe precursor development  
the preparation of cf from alternative precursors based on the known systems as lignins, cellulosics, and polyolefins were under investigation since decades. polyethylene has the advantage of continuous carbon chains in its polymeric structure, which may transfer in good carbon fiber properties. besides, it has advantages in terms of processability and low cost.  
a main achievement of newspec has been the formulation of best bio-pe polymer precursors for carbon fibre processing. this activity was mainly carried out by tecnaro and ditf in collaboration with unexe.  
during the project, several pe materials from different sources (bio-based, oil-based and recycled) have been investigated. after preliminary analysis both recycled pe and oil-based pe were discarded due to uncontrollable quality of the polymer, presence of impurities and unmatched processing features. so, the partners focused on bio-based pe compounds that were developed by tecnaro under the own brand name of arboblend (ab).  
the melt-spun trials of different pe compounds result in stable fibers melt-spinning with low orientation of the polymer chains. an additional stretch of the fibers results in a strength of up to 50 cn/tex and orientations up to 95%. spinnability of the hdpe types is better than in the case of lldpe, but also high molecular weight could be processed. the results achieved in the lab phase allowed verifying the following hypotheses:  
1. lldpe gets something higher carbon yields (up to 47% for carbonization step from sulfur-rich precursor) but less carbon fiber properties;  
2. the hdpe got better carbon fiber strength with maximum of 200+/-40 gpa modulus and around 1 gpa of tensile strength;  
3. lldpe has some drawbacks in melt-spinning (no low-viscosity type available, overall less stable spinning);  
for those reasons hdpe was selected for the upscale in the pilot phase. thus, as result from work in wp2 both polymers ab1639 x and ab1385 x were melt spun at the pilot plant at hpfc.  
the compounding and meltspinning of pe precusor was realized in a semi-industrial scale with up to 8 kg/h raw precursor fiber production volume (figure 1). the process was done with 250 filaments at the time. the higher filament numbers necessary for typical carbon fiber precursors from 1,000 up to 12,000 tows were achieved by joining the yarns together (figure 2 and figure 3). the melt-spinning process in pilot-scale is stable and could be run over some hours without problems with production volumes of theoretical 70 tons/year on the pilot line.  
lot of efforts were done by ditf and tecnaro to set up and optimize the working conditions in order to achieve the best quality pe fibres for cfs making. during the entire newspec programme an impressive number of 350 spinning trials have been performed. this means, on average, a spinning trial every 4,5 days (i.e. one trial per week). in particular, from november 2015 to october 2017, the melt-spinner has worked almost continuously to produce pe fibres for newspec. we calculated that about 710 kg of pe fibres were spun during the pilot phase.  
most of this material has been used for subsequent stabilization and carbonization trials on the pilot line. at that level we observed that some crucial improvements of the pe matrix were necessary. in fact, due to the missing thermal stability of the pe precursor in the sulfur stabilization chamber above 240 â°c it was necessary to modify the pe matrix. therefore, two paths were investigated: i) the addition of nano-agents to improve the fibre crystallinity (see next section), and ii) the melt-spinning of bicomponent fibers. the best results were achieved by using the second strategy, in fact the resulting fibers were mechanical stable up to 270 â°c. however, the bicomponent spinning was limited to the existing spinning line at ditf to only 30-40 filaments at a time.  
  
pe precursor modification by nano-agents and methods for verification of dispersion of nps into a thermoplastic matrix  
one of the goal of newspec regarded the precursor modification by nano-agents. innovative strategies for the reduction of the graphitisation temperature via the use of small amounts of nucleation agents such as carbon nanotubes (cnts), cnws and fine graphite powders have been explored.  
this research area was almost unexplored and so have high risks of success, especially because of the challenging dispersion of nano-agents into the polymer matrix. the main goal was to perform a selection of suitable agents (done at the beginning of the project) and perform laboratory scale mixing trials. this work was started with transforming of natural graphite powder (gp) into graphene oxide (go) using hummersâ method, several dispersion trials were performed but this method was abandoned because leading to poor results. cellulose nanocrystals (cncs) have been successfully dispersed into the pe matrix. for this, unexe has developed, on lab scale, a method for mixing cncs into the pe matrix upon freeze drying and grinding of peo:cnc modified compound (figure 5). this approach has been tested in cooperation with tecnaro and ditf. pe master batches with already dispersed carbon nanotubes (mwnts) were acquired from suppliers upon specifications.  
another idea of newspec partners was to use nano-agents to improve the crystallinity of the pe. the best four samples of unexe prepared precursor fibers have been tested in the continuous stabilization process. there were 2 samples with cntâs included and 2 cncâs. samples with cnc material included could be processed also with lower filament numbers as 250 single filaments in the yarn (figure 6, top). the fiber gluing was reduced in those samples but not removed fully. cross-cut and polished samples showed the not molten, but still sintered filament surfaces of the samples after heat treatment (figure 6, bottom).  
a main challenge was to verify the dispersion of the incorporated of cnc and cnt in melt compounded thermoplastics. unexe has then developed a now quantitative method based on confocal raman mapping combined with chemical images and image analysis to provide a spatial distribution of cncs in high-density poly-ethylene (hdpe) composites. the dispersion of nano-agents in the pe matrix was verified by converting a raman spectrum into a âchemical mapâ.  
the combination of raman imaging with image analysis provides rich information regarding the mixing of hdpe with cncs, and also the agglomeration of the latter in a compounded composite. cncs are found to form different agglomerated islands within the hdpe dependent on the drying process used for their production. raman images provide wider information about the composite quality supported by a detailed chemical quantification and a basic morphological feature of the material. data obtained from the raman images are used to quantify the degree of mixing between cncs and hdpe and the degree of aggregation of cncs. it is worthwhile noting that the average ratio of agglomerated cncs to cncs within an area where mixing with hdpe has occurred can be used as an indicator of aggregation.  
figure 7 illustrates the protocol for the distribution/mixing verification containing three stages:   
- acquisition of the raman spectra - using confocal raman (witec alpha300 r)  
- data processing and generation of chemical images - using witec plus software  
- image processing - using image j software  
the method has been published by unexe in a series of papers and conference contributions (see e.g. a.e. lewandowska and s.j. eichhorn, j. raman spectrosc. 2016, 47, 1337â1342).  
  
from pe precursor to carbon fibres  
1) innovative process for pe precursor stabilization  
pe as carbon fibre precursor is not new, the first patent by sumitomo chemical co ltd dates back to 1974 (us05438704) and was proposing a process for sulfonating pe fibres with chlorosulfonic acid, sulfuric acid, fuming sulfuric acid or a mixture of two or more kinds thereof. this path has been further explored by ornl (ut-battelle llc, us13628463 2012-09-27) who set up a pilot facility in oak ridge, tennessee in collaboration with dow chemical. however, in spite of their attempts, the wet treatment seems to be impracticable from an industrial point of view.  
the main challenge of newspec was to replace the wet (acidic) oxidation employed so far for pe stabilization with a dry method that introduces heteroatoms at the precursor stage and a combination thereof with electron beam curing (ebc) for pe cross-linking (figure 8). the new process has been patented by ditf in 2016 (wo2016170081 a1).  
  
prior to perform trials at the pilot line, single fibre filaments were stabilized using a small home-made laboratory equipment and the best stabilization parameters for preparing the pe carbon fibres were identified. this work run for over 24 months during the lab phase.   
at the end of that phase, we demonstrated that the process could work (proof-of-concept principle, trl 3 equivalent). moreover, the best stabilization method for preparing pe fibers avoiding residues on the precursor fiber surface was found to be a treatment with sulphur-saturated nitrogen atmosphere at a temperature in range of 240-280â°c. an increasing ebc treatment dosage improves in some way the stabilization quality, so no crystalline by-products could be detected in carbonized samples, when the dosage is above 400 kgy. the stabilized precursor has good mechanical stability comparable to pan-based precursor fibres. the well-defined density of 1.77 g/cm3 and the high temperature-resitence to at least 500â°c in nitrogen not independent from the pe source is a sign for a well-defined polymer structure in the precursor fibers.  
we must point out that such a new process requires two crucial ingredients, which were all in all the main focus of the entire programme:  
i) first, the process reaction works only at high temperatures (260 â°c); yet, pe has a relatively low melting point (130-140 â°c). ebc induced crosslinking can partially alleviate the problem but to prevent melting of the pe the precursor needs some additional modification to avoid the sintering of endless fiber filaments during the stabilization. thus, the process only works together a specifically designed precursor which makes the newspec foreground pretty much unique and very strong.  
ii) second, in order to process endless cf fibres, the process requires a special equipment for the sulphur gas-phase stabilization. this is perhaps the most relevant technology created during the newspec programme, as described in what follows.  
  
2) the âsulfiâ equipment  
the treatment of a pe yarn in enclosed inert (nitrogen) atmosphere saturated with sulfur at uniform high temperature - up to 270 â°c - for a long time (several minutes to hours) requires, as said, a special apparatus that has to be conceived, designed, constructed and tested. additionally, gas exchange is necessary for maintaining an equilibrium condition in the gas atmosphere and all surfaces in contact with gas (including the godets) have to have at elevated temperature to avoid sulphur condensation. moreover, the system has to be absolutely sealed to avoid h2s gases to refuge from the chambers and a safety sps has to be implemented to make the system secure and to protect from wrong handling of the system. to do so, the system has to be equipped with reliable h2s sensors and fully automated.  
starting from the very beginning of newspec, dienes apparatebau gmbh has been fully engaged in the development of this system, called âsulfiâ, which consists of two chambers with i) heated walls and with integrated gas circulation with heating for uniform temperature and for reduced heat-up time; ii) yarn transport by heated and tilted godets in duo arrangement for simple string-up and to realize maximum residence time in compact space; iii) adjustable tilting angle to reach optimum degree of space utilization and maximum residence time also for different total yarn titer; iv) heating of godets for uniform treatment temperature of the yarn and for fast ramp-up to operation temperature of the installation; and v) handle exhaust gases.  
during newspec, all the hardware, software and safety systems have been developed, including an external h2s exhaust treatment facility consisting in 4 tons of iron-catalyst who oxidizes h2s to sulphur (figure 9).   
this system was installed by dienes in beginning of april 2016 at the hpcf facility and started to be operational from september 2016. since then, ditf has started the system test phase which is still going on.  
the development of sulfi was extremely challenging for many reasons:  
a. the most important hurdle was to design a oven able to handle the h2s gas generated in the process which is highly toxic. this forced us to ensure that the sulphurization oven has to be absolutely sealed to protect people managing the process. finding the right sealing was not easy.  
b. beside the toxicity of h2s is this gas very corrosive. nearly all metal but stainless steel are not resistant against h2s. the high temperature of maximum 300 â°c is also a technical challenge. most of the sensors, which are available in the market, canât cope with this requirement.  
c. another technical hurdle, which was solved, was that oxygen from the atmosphere which can get inside the chamber by leakage, cracks or the openings where the fiber is been transported into the chamber and out again. the influence of the oxygen reduces quality of the fiber. a second effect caused by oxygen is another dangerous problem. h2s gas with a temperature more than 260 â°c will start burning without a spark when there is only a trace of oxygen inside the treatment chamber.  
the sulfi equipment as whole had to fulfil the machinery directive 2006/42 / ec en 60204-1: 2007 (safety of machinery - electrical equipment of machines) and to ensure full safety of the operators an independent technical audit has been performed by tuv who released its positive assessment report on 30/08/2016. so, the equipment operates today without any safety risk.  
  
3) pe carbon fibres  
laboratory pe-cfs samples, consisting in short single filament cfs, were obtained in newspec at the end of the lab phase (month 24). this was not only a proof-of-concept of the new stabilization process, but also a demonstration that it could be possible to make cfs out of our bio-pe precursor.  
hdpe compounds showed not significantly lower rest masses in carbonization, lldpe have highest rest mass is 47%, which is near the theoretical carbonization rest mass of 54%. in summary, we proved that 73% carbon yield is possible now (against 85% theoretical carbon yield). by contrast, a classical pan-based carbon fibre has around 45% carbon yield.  
the resulting pe-cfs were non-brittle and could be processed without problems as single filaments. the carbon phase was well oriented. waxs data showed a well-developed aromatic structure even in the precursor as in the resulting cfs. best values achieved from hdpe ab 1387 x at a carbonization temperature of 2000â°c with an average strength of 0.83 gpa, a modulus of 96.8 gpa and 0.9% elongation. considering that the small samples were stabilized in lab conditions, these parameters were in line with expected targets on endless pe-cfs. due to the long carbonization time and with applying tension this values should increase. due to this result, better crystallinity maybe improves fibre quality.  
after having reached the wp2 milestone, which demonstrated the conversion of pe single filaments to carbon fibers, and having installed all the required equipment for endless fibre treatment (ebc, sulfi, waste gas plant, carbonization lines, etc.) the newspec work has continued at pilot line level.  
however, continuous treatment of endless pe precursor fibres showed soon strong problems with the weakness of the crosslinked pe fiber bundles and a much stronger problem with the pe fibre sintering behavior (see figure 10), due to the very high temperatures (above 200â°c) required to activate the stabilization reaction path. additionally the fiber sintering prevents the continuous stabilization and carbonization of the fiber bundles, because the sulfur canât diffuse in the inner zones of the fiber bundles and the stiffening yarn tends to break a latest in a second stabilization step necessary to reach the full stabilization of the material, so the fiber samples became very stiff and brittle.  
besides this, several technical issues raised up during the sulfi tests, such as i) lack of sealing and leakages, ii) reliability and durability of temperature sensors, iii) blocking of coolers for sulfur condensation, iv) water inleakage into the chambers and oxygen inbrake into furnaces.  
to solve those problems, newspec partners have been committed for 2,5 years trying to explore all possible technical solutions. although there are still some minor remaining issues, nevertheless major problems have now been fixed and the pilot line is operational.  
low m ...

# NASLA

Project Acronym: NASLA

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('smes', 5)
* ('products', 5)
* ('project', 3)
* ('results', 3)
* ('samples', 3)
* ('impact', 3)
* ('nasla', 2)
* ('coatings', 2)
* ('implants', 2)
* ('dipro', 2)
* ('italy', 2)
* ('agro/food', 2)
* ('equipment', 2)
* ('alce', 2)
* ('calidad', 2)
* ('easreth', 2)
* ('textiles', 2)
* ('personnel', 2)
* ('protective', 2)
* ('systems', 2)
* ('aero', 2)
* ('sekur', 2)
* ('executive', 1)
* ('summary', 1)

executive summary:  
nasla (nanostructured anti-septical coatings) project involved four smes from three different eu countries, having one common technological problem: the need of anti-septic functionality for their products.  
this project aimed at creating new products and knowledge in antiseptic coatings suitable to be applied on a large variety of surfaces; results can have a clear and immediate exploitation potential to improve or develop new products currently commercialized by the four smes: biomedical implants for dipro (italy), agro/food handling equipment for alce calidad (spain) and easreth (greece), textiles for personnel protective systems for aero sekur (italy).  
the work performed and the main results achieved can be summarized as follows:  
-all samples provided by smes (reduced scale samples and prototypes) have been successfully coated by the antibacterial layer.  
-the full characterization of the coated samples has been completed and all of them showed antibacterial activity.  
the final results and their potential impact and use (including the socio-economic impact and the wider societal implications) of the project can be listed as follows:  
-a new antiseptical coating have been deposited on as received polymer substrates (polypropylene, pp and polyurethane, pu) to be used by dipro to produce biomedical implants, in particular, a new artificial anus prosthesis  
- a new antiseptical coating have been deposited on as received stainless steel for food handling equipment to be used in agro/food industry for alce calidad and easreth  
- a new antiseptic coating have been deposited on as received textiles to be used by aero sekur for personnel protective systems, and components for aerospace.  
all the above mentioned products will have large impact both economical (new products for smes) and social (less bacteria-related disease, reduced use of detergents), as stated by smes involved in nasla.

# FUTUREPERFECT

Project Acronym: FUTUREPERFECT

programme & topic: FP7-PEOPLE FP7-PEOPLE-2013-CIG

Most frequent returning words in objectives:

* ('research', 15)
* ('history', 12)
* ('blaszczyk', 12)
* ('fashion', 10)
* ('business', 9)
* ('dichter', 9)
* ('public', 8)
* ('futureperfect', 7)
* ('project', 7)
* ('exhibition', 7)
* ('leeds', 6)
* ('ernest', 6)
* ('consumer', 5)
* ('london', 5)
* ('society', 4)
* ('europe', 4)
* ('papers', 4)
* ('university', 4)
* ('phase', 4)
* ('forecasters', 4)
* ('color', 4)
* ('trend', 4)
* ('catalogue', 4)
* ('programs', 4)

futureperfect (project no. 631789) was a 4-year initiative funded by a career integration grant (cig) from the marie curie people programme of the european commission. it drew on research methods in business history, cultural history, and material culture studies to reconsider the transatlantic history of consumer society. the aim was to advance the historical understanding of consumer society in europe and north america in the twentieth century, and to disseminate this new knowledge to an audience of academics, students, and the general public through lectures, conference papers, and publications.   
the researcher was prof. regina lee blaszczyk, leadership chair in the history of business and society at the university of leeds. this cig helped blaszczyk, who moved to europe from the usa in february 2013, to integrate her specialized expertise in the cultural history of business into the university of leeds, the uk, and the eu. futureperfect centered on the historical study of advertising, marketing, and design practice from the 1930s to the 1990s. the career of ernest dichter (1907-1991), a business consultant who is sometimes called the âfather of motivational research,â was a major focus of the project but not the only focus. the research expanded to explore a range of connections between europe and america from the great depression through the cold war, seeking to develop a better understanding of transatlantic business practices and their interactions with consumer culture.   
in phase i (1 march 2014 to 28 feb. 2016), blaszczyk advanced this agenda with significant research on ernest dichter and the twentieth-century transatlantic business environment. her research focused on the large archive of ernest dichter papers at the hagley museum and library in the usa, and on additional primary historical research on business professionals who were dichterâs contemporaries and sympathetic with his world view, drawing on materials in the usa and the uk. this work allowed blaszczyk to develop a nuanced understanding of dichter and his times, which will feed into the humanistic biography that will grow out of this project. the data-gathering activities of phase i laid the foundation for additional research and writing in phase ii.  
in phase ii of the futureperfect project (1 march 2016 to 28 feb. 2018), blaszczyk continued her work with archival research, lectures, conference papers, and publications. she delved further into the dichter collection at hagley while expanding the scope of the research to other archives in europe and north america. blaszczyk assembled a large body of primary sources, which she used for three major publications: 1) the fashion forecasters: a hidden history of color and trend prediction (london: bloomsbury, 2018), co-edited with professor ben wubs of erasmus university in rotterdam; 2) âpink predictions,â an essay for a exhibition catalogue on pink: the history of a punk, pretty, powerful color (london: thames and hudson, in press for sept. 2018) for the museum at the fashion institute of technology (mfit) in new york; and 3) an essay for an exhibition catalogue on the british fashion designer mary quant to be published in tandem with a major retrospective at the victoria and albert museum (v&a) in london in early 2019.   
futureperfect generated 8 major outputs: 1) the fashion forecasters: a hidden history of color and trend prediction, a 275-page book; 2) collaborations with international museums in new york and in london on 2 major exhibition catalogues; 3) a smaller exhibition and series of public programs at the university of leeds international textile archive (ulita) on the leeds campus; 4) a collaboration with the private corporate archive of the marks and spencer company (also on the leeds campus) on 4 public programs and in teaching; 5) significant original research nearly 30 archives and libraries in the uk, the usa, and austria to advance the cultural biography of ernest dichter; 6) the presentation of 6 public lectures; 7) the presentation of 16 scientific conference papers and commentaries; and 8) the growth of a major international research network.   
one major outcome of the research project was for blaszczyk to develop a complex understanding of transatlantic consumer society from the great depression of the 1930s to the end of the cold war in the early 1990s. intensive research in archives and libraries in the uk, the usa, and austria engendered blaszczyk with a deeper appreciation for the history of retailing, merchandising, branding, and marketing. these themes were all central to the life and times of ernest dichter. moving forward, blaszczyk will be able to write a nuanced, archives-informed analysis of dichter and other business consultants who helped european and american enterprise understand transatlantic consumer culture.   
  
a second major outcome of futureperfect was the creation of educational materials that are interdisciplinary in scope. the major published output of the project was the fashion forecasters, a 14-chapter anthology that combines 9 research chapters by historians, cultural geographers, and anthropologists with 5 oral history chapters built around biographical oral histories of contemporary trend forecasters. blaszczyk co-authored the historical introduction and conclusion, wrote 2 historical chapters, and created all 5 of the biographical oral history chapters. the objective was to link the past to the present as a heuristic device that might lead students and fashion practitioners to think critically about the origins of contemporary trend prediction and color forecasting.   
a third distinctive feature of futureperfect was the effort to bring academic research to non-academic audiences, building on blaszczykâs experience in museums, heritage, and public history. on the leeds campus, two public engagement efforts were developed: one with ulita, and another with marks and spencer company archive. the ulita collaboration produced an exhibition on the synthetics revolution: man-made fibres and everyday fashion and a series of related public programs. the collaboration with the marks and spencer company archive resulted in 4 public programs on everyday fashion. blaszczyk also developed partnerships with museums in new york and london that have an international reach. her work with the mfit led to her chapter in an exhibition catalogue on pink. her collaboration with the v&a resulted in blaszczyk writing an essay on the international fashion business for an exhibition catalogue on the fashion designer mary quant. futureperfect came full circle with this project, as mary quant admired ernest dichter and praised his ideas about intuition and entrepreneurship in her autobiography.

# LEGIOTEX

Project Acronym: LEGIOTEX

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('filter', 24)
* ('system', 20)
* ('control', 18)
* ('water', 16)
* ('systems', 14)
* ('legionella', 12)
* ('fabric', 11)
* ('legiotexwater', 10)
* ('bactericide', 9)
* ('legiotex', 8)
* ('project', 8)
* ('head', 7)
* ('distribution', 6)
* ('biocide', 6)
* ('smes', 6)
* ('sector', 6)
* ('fibres', 6)
* ('optimum', 5)
* ('installation', 5)
* ('behaviour', 5)
* ('loss', 5)
* ('relation', 5)
* ('equipment', 5)
* ('opportunity', 5)

the general objective of legiotex is the development and validation of legiotexwater filtering system, a novel, cheap and certifiable prototype of filter and control system for continuous bactericide filtration and control to inhibit the growth and proliferation of the bacteria belonging to the legionella pneumophila family in water in close-circuit cooling towers and drinking water distribution systems which accumulate water and spread it as an aerosol in risk of becoming a source for legionnaire's disease outbreaks in large public and industrial facilities.   
  
 for developing the aimed filter, environmental-friendly bactericides have been appropriately fixed onto nonwoven textiles, assuring a long lasting biocide effect and optimum mechanical properties. the filter has been mounted onto reusable cartridges for its easy installation in different equipments, optimum fluid-dynamic behaviour and successful commercialisation. the control system is able to detect if the bactericide rate and head loss are being kept at constant levels in order to run the appropriate alarm or action if reaching safety risks in relation to legionella concentration or impacting the mechanical behaviour of the water system being treated.   
  
 legionella is present in all aqueous media. however it becomes a threat for human health when appropriate conditions for its growth and proliferation are met, which frequently happens in large in-doors facilities using systems for climate control: cooling systems, sanitary water distribution equipment (tanks, boilers, heaters pipes and point-of use) and other equipment subject to similar conditions (irrigation, fountains, etc.).   
  
 during the period 2003 and 2004, a total of 9166 cases of legionnaire's disease were reported by 35 countries in the european geographical context. the overall mortality rate was 8.2 %, increasing to a 40 % for immunocompromised patients (i.e. in hospitals). within this scenery, increasing regulation for the installation, operation and maintenance of climate control equipment and water distribution systems in relation to legionella has lead to the requirement for more effective bactericide systems. legiotex is an opportunity for small and medium sized enterprises (smes) in the sector to improve their competitive position by developing an innovative product able to prevent legionella outbreaks, which complies with applicable normative and minimises installation and maintenance costs. legiotex will also be an opportunity for smes in the textile sector, allowing for a high-tech application of nonwoven fabrics and finally smes in the bacterial detection sector, by developing a real time biofilm monitoring system for legiotex.   
  
 project context and objectives:   
  
 legiotex project has gone through the design, manufacturing, assemblage and preliminary testing of five legiotexwater filtering system prototypes looking for to reach a bactericide rate of 75 % in relation to legionella concentration and a life span of six months. legiotexwater system consists of two main components: the filter and the control system. the filter is composed by the nonwoven filtering fabric and by the cartridge geometry where the fabric is housed. the control system integrates the real-time biofilm and head loss monitoring system, the control of the backwashing mechanism to clean the filter and the wireless communication device to transmit data remotely.   
  
 for the main part of legiotexwater, the nonwoven fabric with treated fibres, a deeply research work and laboratory testing on fibres and filter fabrics has been performed by ti, minerva, stellini and logrotex. the best composition of materials, geometry for the fibres and the optimal nonwoven fabric structure were deeply analysed. in addition, the best functioning of the filter in terms of bactericide and mechanical behaviours have been fully analysed and reported. the research work and conclusions has been fully described on the project confidential reports.   
  
 concerning the cartridges prototypes to house the fabric and compose the filter, different concepts and prototypes of geometries have been generated by itav with the support of idrodepurazione and deeply described on the confidential reports, always looking for housing the nonwoven fabric in the most efficient way to obtain the best filtering performance. it includes minimising the pressure drop to not disturb the normal operation of the water system, maximising the effective filtration area to ensure a uniform use of the filter volume and a release of the maximum effective quantity of biocide, avoiding dead zones and premature waste of the fabric, achieving the longest resident time or contact time between the biocide and the water to allow the correct inactivation of bacteria and finally, taking into account the complexity of manufacture and price / availability of materials.   
  
 regarding the technological objectives of the project, we can asset that the limits of filter porosity has been clearly established to ensure the 75 % bactericide effect or reduction in legionella concentration. the filter is a self-cleaning device due to the automatic backwashing mechanism controlled by the control board that removes the particles trapped into the fibres using a backwashing mechanism. a two stage filtration using hydro-cyclonic is required to lower the solids load to the final low porosity treated filter for long time operation between backwashes.   
  
 the nonwoven filter is formed by solid fibres treated with environmental-friendly legionella biocides. the best composition in terms of efficiency and manufacturing price has been established eliminating 100 % of legionella/ml after 30 minutes treatment. it can also eliminate other types of bacteria, fungus, etc. leakage of biocides from the treated filters into water is relatively low and all below the world health organisation (who) drinking water maximum concentrations for these materials. the final sheets of nonwoven fabric (pl686 and pl687) are within the range of thickness of 0.1 to 15 cm. the fabric is chemically inert, non-noxious and recyclable. the resin is not biodegradable; however it can be moulded and reused many times or used as a fuel burning without pollution.   
  
 several prototypes of filter cartridge have been simulated and five of them manufactured for testing. head losses depend mostly on the nonwoven fabric thickness (increasing it and lowering the porosity will increase the head loss of a filter) however the designs are always keeping the head losses lower than 30kpa (at around 13kpa). each prototype develops a different engineering design or geometry, adapted to optimise the filter behaviour to the different systems addressed. each one is using a different filtering concept: four of them using hydrocyclonic and cylindrical concepts for pipes and tanks filtering on cooling towers (hydrocyclonic) and drinking distribution systems (cylindrical) and the last one a bactericide filter for hand showers on sanitary water systems. all them are scalable so can be adapted to any kind of water flow by just adapting their dimensions, number and position of filters.   
  
 the filter and control system are mounted allowing for the reusability of the cartridge after the life span of these components. the nonwoven filter is easily removable and exchangeable from the cartridge. the control system has been developed as a modular component to allow a total flexibility for use of legiotexwater, optimum maintenance practices and maximum market opportunities for the sme partners. the sensors helps to control the biocide and mechanical functioning of the filter by the detection of a biofilm growing and head loss increasing and by activating the backwashing mechanism if necessary. however, the filter could be installed and work without these elements by using some external and periodical control measures. the control system is a real-time biofilm detection system, with a head loss monitoring device with a minimum accuracy of â±10 pa and a wireless device, to transmit data remotely.   
  
 project results:   
  
 legiotexwater is a filtering system capable to inhibit the growth and proliferation of the bacteria belonging to the legionella pneumophila family in water-based systems for large public and industrial facilities. for this purpose, environmental-friendly bactericides have been fixed onto nonwoven textiles assuring a long lasting biocide effect and optimum mechanical properties. the filter has been mounted onto a reusable cartridge for its easy installation in different equipment, optimum fluid-dynamic behaviour and successful commercialisation. and an electronics control system has been developed in order to monitor in-situ the efficacy of the filter in relation to bactericide efficacy and mechanical behaviour and run real-time alarms or actions. legiotexwater filtering system is a novel, cheap, cleaner to operate, easier to be installed on-site on broad range of water-based systems (i.e. cooling systems and water distribution systems), with scientifically validated reliability and complying with applicable legislation and standards.   
  
 potential impact:   
  
 the legiotex project is of great relevance to the sme partners in order to improve their competitiveness in the world arena and face the main market trends described for the sectors in which they are present. it will be an opportunity for smes in the water treatment sector to improve their competitive position by developing an innovative product able to prevent legionella outbreaks, which complies with applicable normative and minimises installation and maintenance costs. it will be an opportunity for smes in the fibres / fabrics manufacturing textile sector, allowing for a high-tech application of nonwoven fabrics using an environmental-friendly biocide for legiotex. and finally, it will be an opportunity for smes in the legionella detection sector, allowing for a high-tech electronics control system development.   
  
 related to the target or primary market the project is addressing: close-circuit cooling towers and sanitary hot water distribution equipment (pipes, boilers, heaters, tanks and endpoint of use) for climate control in large public and industrial facilities (hospitals, hotels, spas, agro-food industrial plants, etc.), logrotex and idro estimate a total 30 % market share after the first five years commercialising legiotexwater. a 10 % profit margin has been considered by sme providers along the value chain (stellini and minerva), in accordance with production costs foreseen in relation to the price of raw materials and manufacturing costs derived from other products in the partners' portfolios. logrotex estimates a 20 % profit margin and idro a 30 %.   
  
 the successful exploitation legiotex will have an important impact on health and safety at european level by a yearly reduction of 1500 legionnaires' disease cases and 150 potential deaths, which will mean savings of up to eur 300 million to the european economy. for operational monitoring and risk management, regulations for control of legionella rely on measuring parameters that show whether systems are working properly. legiotexwater will strengthen this approach being a preventive continuous system with real-time monitoring of bactericide efficacy. finally, legiotexwater will help reducing the environmental pollution related to water treatment systems from the use of biodegradable biocides and reducing the generation of industrial waste by being developed as a recyclable filtering fabric and reusable cartridges structures.   
  
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# LION-TEX

Project Acronym: LION-TEX

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('lenticular', 66)
* ('image', 40)
* ('images', 31)
* ('textiles', 29)
* ('process', 26)
* ('software', 26)
* ('resin', 24)
* ('resins', 20)
* ('textile', 19)
* ('visibility', 17)
* ('layer', 17)
* ('effect', 16)
* ('effects', 16)
* ('ink-jet', 16)
* ('parameters', 16)
* ('order', 15)
* ('shape', 14)
* ('output', 14)
* ('safety', 13)
* ('printer', 13)
* ('number', 13)
* ('project', 12)
* ('printing', 12)
* ('lenses', 12)

executive summary:   
  
 the lion-tex project represents a breakthrough innovation in the field of textile printing. the step forward is represented by the possibility of bringing onto textiles the three-dimensional (3d) effect of lenticular images, and exploiting it for improving the efficiency of high visibility safety garments and devices.   
  
 the lenticular effect is a well-known technology that allows reproducing a few 3d effects on flat surfaces. two or more images are interlaced (i.e. 'cut' into very narrow stripes and put together, alternating one stripes of the first picture and one of the second) and covered with a lenticular layer, that is a transparent sheet, shaped as an array of semi-cylindrical lenses. each semi-cylinder covers exactly the two (or more) interlaced stripes, acting as a magnifying lens: this way, the observer's view is focused on one of the picture, depending on the relative position. when the observer relatively moves respect to the lenticular image, he can see the picture changing.   
  
 the technology developed in the lion-tex project allows to recreate this effect on textiles, with an efficient, cost effective and robust innovative printing machine. the machine is basically composed by a common ink-jet printer for textiles, a dryer, a second printhead for resin dispensing and an ultraviolet (uv)-curing light for freezing the resin. thanks to this innovative machine, the lenticular images (and textiles) production process is a lot simplified:   
  
 - the textile is positioned by the carpet.   
 - the ink-jet printheads print the interlaced image on the surface of the textile.   
 - the ink-dryer passes over the textile and fix the ink on the surface.   
 - the resin dispenser is positioned over the interlaced part and covers the image with an array on lenses.   
 - the uv-curing system freezes the dispensed resin so that it maintains the wanted shape and curvature.   
 - the lenticular textile is ready and the carpet advances for the production of the next portion.   
  
 the overall savings of the new process are a breakthrough. first of all raw materials: the polymeric array of lenses is directly built on the surface, 'on-demand', and so there is no more need for shaping and cutting pre-formed rolls and no more waste produced. the energy needed for forming the lenticular layer is much lower (up to 1:50) than that used for extruding the polymeric film and calander it into the final shape. furthermore, being everything integrated and synchronised in one machine, there is no time needed for fine positioning and combine the printed image and the lenticular layer.   
  
 beside all possible future applications of this new technology, the high visibility effect for safety garments is the one with the highest potential and gain.   
  
 high visibility garments (for example drivers emergency jacket) are commonly made of polyester textile very bright coloured (yellow, orange, green) and some reflective stripes. the lenticular plotter enables the creation of a new generation of safety garments characterised by an enhanced high visibility effect; the jacket, or part of it, is coloured with an interlaced bright image (e.g. green and yellow) and covered with the lenticular layer: all observers, depending on their relative position and movement, will see a colour-changing high visibility jacket, with a 'flashing' effect from green to yellow that will capture much more their eyes. human eyes, in fact, respond quicker to dynamic effect instead of static, so lenticular effect can really enhance the properties of safety garments.   
  
 the project accomplished all its objectives and developed a demonstrator of the lenticular plotter, not ready for commerce yet but able to produce small lots of lenticular textiles and a first prototype of lenticular high-visibility garment.   
  
 project context and objectives:   
  
 the need for safety:   
  
 as stated by the european agency for safety and health at work (osha) and the canadian centre for occupational health and safety (ccohs) , high-visibility safety apparel (hvsa) is essential for people that work when there is low light and poor visibility and, in particular, where the working place involves moving vehicles.   
  
 the human eye responds best to large, contrasting, bright or moving objects: that is why high-visibility items allow people to be seen by drivers sooner and more readily. at the state of the art, worker visibility is enhanced by high colour contrast between clothing and the work environment against which it is seen.   
  
 in order to address this issue and minimise accidents, the european union (eu) directives 89/656/eec and 89/686/eec, which oblige employers to make available high visibility clothes to their employees.   
  
 in europe 16 million workers operate in low-visibility environments, including roadway construction personnel and vehicle operators, utility workers, survey crews, emergency responders, railway workers and accident site investigators, school crossing guards, parking and toll gate personnel, airport ground crews and law enforcement personnel directing traffic, parking service attendants, workers in warehouses with equipment traffic, shopping cart retrievers, sidewalk maintenance workers, and delivery vehicle drivers, to name a few. statistics report that every year 6 000 of them are injured by vehicles or human operated equipment, because of a lack of visibility, especially in night time operations.   
  
 state-of-the-art solutions consist in applying reflective material stripes onto the garment surface. these stripes are made of an open lens type reflective film consisting of high index reflective micro glass beads on a background of fluorescent material. however this passive solution is not effective if we consider that a recent study highlighted that the main cause is the late detection by the driver, since the vehicle lights are not able to illuminate effectively the side of the road. this is in agreement with much anecdotal evidence from the roadside after vehicles have hit pedestrians. after hitting pedestrians at night, many drivers claim that they never saw the pedestrian, often reporting that the impact was the first warning they had of their presence. over the cost in human lives, also the social cost for persons injured has to be taken into account: estimating 10 days hospitalisation and the costs for rehabilitation (the mean costs per inpatient day were eur 230 (range: eur 154 - 311) in general hospitals and eur 323 (range: eur 209 - 400) in university hospitals) , and 30 days inability to work (conservatively eur 60 per day), it is possible to state that, globally, these accidents do account for a cost conservatively, eur 30 million per year related to such accidents.   
  
 therefore, in spite of the norms and the attentions paid in the last 20 years, a lack of security in garments for workers is perceived. this technological gap can be filled thanks to innovative way of thinking the textile substrate. the textiles and clothing industry is one of europe's leading industrial sectors and, in particular, the technical textile industry represents a greater and greater percentage of the total production of western europe countries.   
  
 the need for technical textiles:   
  
 the worldwide consumption of fibres for technical applications was around the 40 % of global consumption, that is 29 million tons on 72.5 million tons with an overall value of usd 130 milliard. the growth foreseen in next decade is of about 2.1 % every year, challenging 89.3 million tons in 2020. in a general panorama of decline for the textiles market (- 25 % from 2000 to 2010), the technical applications have turned out substantially stable (- 5 %, comprehensive of effect crisis).   
  
 the evolution of the technical textiles market for europe is foreseen to be stable in next years, with the production volumes on the levels of the 2008 (cirfs, 2011), equal to approximately 6 % of the worldwide production of technical (approximately usd 7.8 miliard in 2010) (bch, 2011).   
  
 the german market is a good reference to figure out the economic trend of high quality technical textiles in the euro area.   
  
 from 2000 to 2008 (before the crisis) the total textile production has decreased of around 17 %, while the technical textiles production has increased, in the same period, of 22 %. from latest results of 2011, so including the figures of the recent recession, we can say that the production of textiles has suffered an overall decrease of - 25 %, while technical textiles has increased the production of 22 % (data 2001 - 11).   
  
 according to these figures, despite the large volumes of textiles for fashion and apparel are migrating to asian and brazil, russia, india and china (bri)c countries, the production of technical textile remains one of the stronger asset of european manufacturing industry.   
  
 among the other technical textiles, industrial protective clothing market in europe and the united states of america (usa) together share the greatest percentage of the global market. rising emphasis on worker health/safety issues, stricter government mandates, technology innovation, and increasing pressure to reduce costs associated with workplace related injuries led disability and death, will stimulate the world industrial protective clothing market to reach usd 7.7 billion by 2015.   
  
 europe still represents a major producer of technical textiles, supported by the technological gap with emerging countries: that a niche added-value market, european manufacturing system shall maintain inside the boundaries.   
  
 the growth of the need for safety textiles in asia will be driven by new manufacturing works and construction projects underway in middle east, and asia, particularly, india, china, and vietnam. additionally, apart from being the world's most populous countries, china and india have a large number of unprotected industrial workers and this offers a further potential for future growth.   
  
 this can represent an opportunities, for the smes involved in the 3d lion project, to increase the technological gap with emerging countries and increase their competitiveness in such a difficult, but very large, market of safety textiles and garments.   
  
 the project idea:   
  
 the lion-tex project is based on an innovative method of producing lenticular pictures, which allows them to be directly created on non-flat or bendable surfaces like textiles, thus realising lenticular effects even on textiles, by creating a lenticular layer of a transparent resin directly on it.   
  
 a particular printing method is represented by lenticular images, a very well-known technology, exploited in many fields such as photography and postcards, commercials and a great number of gadgets. lenticular images are optical effects created by coupling a digitally treated picture (interlaced picture) and a layer of lenses (lenticular layer); the typical optical effects that can be reproduced are flip, morphing, zoom, 3d and moving effects.   
  
 usually lenticular images consist of two elements: a digitally modified image, which is called 'interlaced picture' and a layer of lenses called 'lenticular sheet', which is produced by extruding a flat layer of plastic which is then thermally deformed by a calandra, in order to assume the shape of the required lens. the interlaced picture is usually printed on a substrate of plastic or paper and the layer of lenses is glued on it; sometimes the interlaced images can even be directly printed on the flat surface of the lenticular substrate. at the state of the art, when lion-tex began, lenticular images were not exploited in textile industry, neither for fashion scope nor for high visibility function. with the current technology, it is rare to find applications on textiles and, in any case, they just consists of a patch, welded or sewed, which is not a fully integrated part of the garment. a lenticular patch can strongly affect the rigidity of fabric with two bad effects: it modifies the wearability of garments and it difficultly exploits the continuous 3d movements and bends of flexible textiles. moreover, the patch cannot recreate a particular shape (a logo, a stripe, a basic shape) without a waste of materials: the lenticular sheets are usually squared and they shall be cut, adjusted and most of them are just thrown as process waste.   
  
 the innovative process consists of 2 fully integrated process steps:   
  
 (a) interlaced image is generated by dedicated software and then printed on the textile with an ink-jet printer;   
 (b) lenticular layer is created with an ink-jet dispenser machine, which is able to treat resins with high viscosity and to build 3d patterns.   
  
 in this way, lenticular layers can be easily created on every material, plastic, paper and textiles, introducing new opportunities of application. the innovative method of creating lenticular printed textiles can be exploited for safety purposes, adding to the common high visibility effects an additional 'flashing' effects that represents an extremely important added value.   
  
 the process is industrialised in a lenticular automatic plotter.   
  
 the very interesting reached results convinced the owner of the idea (and of the previous patent lion-tex is based on) to go for a second patent and secure the concepts and the technologies of the lion-tex lenticular plotter.   
  
 project results:   
  
 in line with the above mentioned needs, lion-tex partners have set-up and performed three key research areas, namely:   
  
 - the software: interlacing software should manage innovative lenticular effects, related to the 3d, bendable surfaces: the shape of lenses should be re-designed and optimised, first of all to adapt them to 3d surfaces and then because of the new optical effects provided by new interlacing software. gathered results: a simpler and user-friendly software has been developed, to generate lenticular images; an innovative software for integrating lenticular images onto image files; an innovative printer rip, that enables the translation of image files (\*.jpeg; \*.bmp; \*.tiff) into a binary file that controls plotter and printheads movements.   
  
 - the process: resins had to be investigated, in order to find the ones possessing the right requirements for this application. the most suitable resin for lenticular effects must be transparent, dispensable by ink-jet printheads and flexible enough to be coupled to fabric substrates without cracking. the largest number of resins tested was uv-curable resins: they should cure as fast as possible and, at the same time, avoid the proclivity to become yellow, as ageing effect. moreover, the normal usage of printed fabric or garments should be investigated, in order to figure out the possible effects on the resin of common operation on textiles like washing or ironing, and avoid any possible related risk. the ink-jet resin dispenser should be integrated into a common ink-jet textile printer, in order to create a demonstration machine which allows at first step to print the interlaced image on the fabric, and then to print on that image the lenticular lenses, without moving the substrate to other machine or process station. this integration allows saving time in the printing process and decreases the need of calibration between the interlaced image and the lenticular sheet. the lenticular layer created by the ink-jet dispenser depends on several machine parameters and it should be optimised, in order to perfectly fit with the interlaced image. gathered results: a set of new resins has been developed and the results of test on textiles demonstrated the feasibility of 3d lenses creation on the surface.   
  
 - the product: the final products, fabrics and clothing, should be tested as described in the reference norms, and grant a higher visibility effect for improving safety in dark low contrast environments. gathered results: several samples of lenticular coated textile have been produced (and are still being produced by vogue). the garment has not yet been tailored, but the consortium is ready to.   
  
 in order to overcome the previously introduced technical barriers, key scientific and technical objectives have been set in each of the three areas, by the consortium: software and control, the lenticular process itself and the high visibility textile.   
  
 as far as the software is concerned, the objectives targeted in the proposal have all been accomplished within the project.   
  
 - management of innovative lenticular effects: at the state of the art, different software can be exploited to create a flat interlaced image, by introducing only few parameters that describe the kind of effect one wants to obtain. the problem related to the lenticular printing on textile is that the software should interlace the images while taking into consideration that the substrate is not flat and it can be bent. the developed software can manage the whole process, from the creation of the interlace picture, to the requirements of lenticular arrays, to the synchronisation of the two printheads. other basic shape interlacement: pictures are 'cut' and joined together along a basic shape required by ppe garments. the software allow to create an interlaced picture and insert it onto a not interlaced background, in order to ink-print the background and create ad-hoc patterns on the interlaced part of the image. thanks to the developed software, the two printheads can be controlled in a synchronised way, for best results.   
  
 definition of patterns: the software can even calculate the optimised patterns (dimensions and parameters of the lenses, geometry of patterns) and send to the ink-jet dispenser the correct information to create the required lenticular sheet.   
  
 - accomplished mission: developing the software we have been concentrated on creation the interlaced images for the cylindrical lens structure because it seems to offer the most promising applications in the textile industry. the software creating the interlaced images will be easily adapted for the other types of lenticular structures. the software allows a user to design an interlaced graphics to work together with lenticular lenses of fitted structure resolution. the lens must be perfectly aligned with the image.   
  
 typical graphics is a composition of two or more interlaced images, which constitute one picture.   
  
 the software is universal and can be used for preparing interlaced images for all mentioned above various lenticular effects.   
  
 in the software, the interlaced image is composed from a few input images. the result depends only on the content of the input images introduced by a user. the software is optimised for a few parameters, which can be selected according to requirements. a user can choose between a few typical printer resolution values (dpi) and different lenticular lens 'resolution' values (lens per inch (lpi)). it is also possible to set the size (in mm) of the output image and the software can control this parameter and required proper dimensions of the input images (in pixels).   
  
 from the relationship dpi to lpi the software calculates the maximum number of images that can be interlaced. a user can chose arbitrarily a number between 2 and the maximum. the number of the input images is the number of 'frames' in the output image. all images are 'bmp' type.   
  
 all parameters described above determine the image pixel dimension. this parameter refers to angle sensitivity of the output image. a user can chose between 1 and the maximum (calculated by the software). the smallest selected number corresponds to the highest angle sensitivity. if the result of multiplication of the image pixel dimension and the number of images is not equal to maximum number of images the software will automatically add a proper number of background pixels. an operator can also select a colour of the background. the interface contains six panels:   
 (1) the printer resolution;   
 (2) the output image dimension;   
 (3) lenticular lens resolution;   
 (4) load images;   
 - image pixel dim;   
 (5) create output image;   
 (6) on the left side and the image display area for loaded bitmaps - on the right.   
  
 the subsequent sections will contain the description of panels functions.   
  
 resolution of the printer: the printer resolution can be selected using the selection list located in the printer resolution panel   
  
 the printer resolution (dpi) is the master parameter. it defines constraints between itself and two other parameters i.e. maximum number of images (maxno in load images panel), maximum dimension of the image pixel (max in image pixel dim panel). these parameters can be also selected by an operator within allowed ranges, otherwise default values are applied. consequently the above parameters modify the output image dimensions given in pixels. all selected values are displayed in create output image panel.   
  
 dimension of the output image: the physical dimension (mm) of the output image can be changed using the edit boxes in the output image dimension panel. the default value is a4 format. any change of the height or width values results in change of dimension values in pixels.   
  
 change of the width of output image in mm (output image dimension panel) from 210 to 420 results in the change of the output image width in pixels and the change to description from 'w4960 pix' to 'w9921 pix'.   
  
 the resolution of the lenticular lens structure can be selected using the list placed in the lenticular lens resolution panel. any modification of lpi affects the value of maximum number of images (the maxno value in the load images panel) and the value of maximum dimension of image pixel (the max value in the image pixel dim panel). if the lenticular lens resolution is not specified by a user program runs with the default value i.e. 40 lpi.   
  
 the software creates two images, starting from two (or several) initial bmp files: the images 'username.bmp' which contains the interlaced image and the 'username\_lenticularlens.bmp' which contains the shape of lenticular structure. both images are saved on a hard disk and are not shown in the main screen of the programme. the software is user friendly. users should set or select the process parameters starting from the top panel and go subsequently to the bottom panel.   
  
 the lens printing parameters should be discussed in the next project stage when the image/lens printer is developed.   
  
 the whole process was initially validated at lab scale, but it still needed efforts to be put at industrial level: in particular it was necessary first to develop the resin(s) and the dispensing device and then to start the integration on a common industrial plotter for textiles.   
  
 many improvements were required on the resins.   
  
 optimisation of basic characteristics:   
  
 the resins needed to create a lenticular sheet must be completely transparent and participate, with their optical behaviour, to the success of the lenticular effects. moreover, since they are going to be dispensed on non-flat textile substrates, the resins shall be soft, in order not to stiffen too much the zone where they are applied and, they shall be bendable, for avoiding the risk of pattern cracking and, at the same time, they should not be absorbed by the fabric during the printing process. thickness of the lenticular layer has to be in the range 0.2 to 1.4 mm, the radius of curvature for the lenses is to be evaluated and designed in accordance to the optical requirements.   
  
 anti-ageing additives: the first products that have been preliminary tested are uv curable resins, since those resins have the great advantage, with respect to other kind of polymers, to cure rapidly. the risk is related to the effect of ageing: uv curable resins are very sensitive, even after the curing phase, to uv radiation and they tend to become yellow or dark because of the exposition to the sun. innovative formulations or additives can avoid or at least slow this ageing process and give to the lenticular printed fabrics a longer life. faster cure process. in the printing process that has been preliminary designed, the uv resins have a two-steps curing phase. every drop of resin ejected by the dispenser is hit by a very concentrated uv spotlight, in order to maintain the required shape, instead of being absorbed by the textile or being smoothed by its own weight. this preliminary curing phase is not enough to completely fix the printed layer, it is necessary a second step tin which the fabric is exposed to a uv radiation source for a longer period. the best suitable resin for lenticular printing shall reduce these phases as much as possible: a 10 mw / cm2 lamp can cure an area of 1 cm2 in about 80 - 100 s, with a high power lamp, 50 - 100 mw / cm2 the same area is cured in 15 - 20 s.   
  
 ink-jet dispensable:   
  
 not all materials are suitable or easy to be treated with ink-jet dispensing systems; these devices require the liquids to be dispensed to grant some physical parameters which should belong to a precise range of values, in order to make the jetting process work. one of the most important parameters is the viscosity of the fluid: since the connecting tubes and mainly the orifice have very small diameters (less than 100 microns) the fluid shall have a viscosity similar to water (1 cps) to be easily treated. if the viscosity of the fluid grows over a certain limit, depending on the geometry of the dispensing device, it is necessary to reduce it, for example with heat. in some difficult cases heat is not enough and chemical additives are necessary to reach that target.   
  
 bendable and suitable for textiles:   
  
 the substrates on which the resins are jetted are not flat: they can be 3d shaped and further more they can be bent. the printed layer, and so the resin, shall follow the fabric in its movements, remaining always tight fitting and avoiding the risk of break. the parameters that shall be studied and optimised were:   
  
 - viscosity of the resin: jetting devices work well when the material to be dispensed has a viscosity in a range of values very close to 1 cps; more viscous materials (up to 100 cps) can be treated by heating them up until their viscosity becomes lower and suitable for jetting.   
 - speed of curing process: in order to create the lenticular layer, the resin is cured in a two-steps process. spot-light freezes the dots of resin on the substrate which maintain the shape until the end of the deposition process and then the whole lenticular layer is cured with a uv lamp. it is important that the curing process is as fast as possible, to avoid the risk of deforming the original shape of the dispensed dots and for speeding the industrial production.   
 - stability to uv radiation: it is the most common contradiction for uv curable resins. uv radiation activates the polymerisation of the resin but, when the curing process is completed, it still has an impact on the resin: uv is the main cause of ageing of resins, which become yellow and opaque.   
 - resistance to normal life cycle of clothing products (washing, drying, folding).   
  
 - accomplished mission: urethane acrylate: we synthesised different resins and three of them were selected and formulated with different reactive diluents:   
  
 (a) resins: (bencryl urethane acrylate a (141).   
 (b) polyether polyol urethane acrylate based on aliphatic di-isocyanate.   
 (c) bencryl urethane acrylate b (137).   
 (d) polyether and aromatic polyol urethane acrylate based on aliphatic di-isocyanate.   
 (e) bencryl oil urethane acrylate c.   
 (f) oil base polyol urethane acrylate based on aliphatic di-isocyanate.   
  
 for the epoxy-acrylic oligomer we worked with a liquid epoxy resin making the reaction with acrylic acid. all resins were diluted in many different reactive diluents in order to find the best compromise of applicative requirement and final performance.   
  
 the fabrics tested, hyppolux (polyamide 100 %), texas (cotton 100 %), ramona, (cotton 97 % elastane 3 %) asia (rayon 93 % elastane 7 %) , sensitive( no indication) were supplied by vogue service sa.   
  
 to check resins performances regarding reactivity, adhesion, yellowing, hardness, flexibility they were formulated with photo initiator and were applied on the fabric by using a bar coater (90 mills thickness) and cured using a mercury lap (80 w) with speed of 4 m / min for two times also the fabrics behaviour under uv exposure were observed.   
  
 the conclusion of the tests can be briefly summarised:   
  
 (1) from results reported we can conclude that either resin type oil urethane acrylate or epoxy acrylate combine characteristics of adhesion, reactivity, transparency that indicate as candidate for the application.   
 (2) both synthesis process can be scaled up and are reliable.   
 (3) for the oil urethane acrylate, 50 % of row material comes from renewable source.   
 (4) some yellowing was observed on texas, ramona and asia fabrics.   
  
 the printheads. at the state of the art, there are already ink-jet dispensing systems suitable for treating fluids like the resins above described. anyway a deep optimisation of these systems was crucial, to make easier the integration with the ink-jet printer for textiles and in order to grant the complete success of the whole project:   
  
 - optimisation for resin printing: the testing machine used for preliminary validation tests was a very versatile lab machine, the typical jetting parameters which could be set in a wide range of values, to be suitable to perform tests on many materials. once that the resin(s) to be used have been confirmed, the dedicated printhead has been selected to fulfil the request for that material. the geometry of the reservoir, the tubing assembly, the heating system, the curing uv spotlight, the geometry of the orifice and the parameters of the electric wave input (voltage, current, frequency, shape of the wave) have been customised.   
  
 - creation of 3d layers: usually ink-jet dispensers are used to print very thin flat films of materials, which create a picture, a printed circuit or gaskets. in this application it is important that the printed film has a certain shape, to allow the observer to see the lenticular effect. for this reason it is important to study how jetting parameters affect the profile of the lenticular sheet, the thickness, the flexure and its radius.   
  
 as a final result of the project, in which all the improvements are summarised, the dedicated ink-jet dispensing device has been integrated into a common ink-jet printer for fabrics, as a demonstrator, to show how the process can be industrialised.   
  
 the proposed solution foresees the printing phase with the rolling carpet stationary and the two printheads independent from each other, that can move along the print area in the two plan direction one by one. once the print area is completed, the rolling carpet can move forward for a distance equal to the printing area length. this solution eliminates the interdependency and the relative incompatibility between the two printheads.   
  
 version hs-b (high speed) of the plotter allows you to print at high quality with a variable speed from 20 to 40 (m2/h). the lion-tex version also allows to control resining head in order to deposit drops of resin on the basis of the reception of the drawing data and on the reading of the current position of the head itself. via input / output digital signals, the resin deposition phase is handled synchronising the deposition pulses with the actual position of the head and on the basis of design data acquired.   
  
 the lion-tex plotter consists of the following groups:   
  
 (a) axial unwinding with pneumatic brake in controlled pull;   
 (b) braking group;   
 (c) plotter;   
 (d) device for the deposit of resin;   
 (e) rug for fabric transportation;   
 (f) rear heater;   
 (g) cleaning removable device for the carpet;   
 (h) winding system;   
 (i) ink supply system;   
 (j) ink recovery tank.   
  
 the high visibility products:   
  
 the lenticular pictures are potentially interesting for many innovative applications. first of all, from the point of view of protection clothing, the lenticular effect can contribute to high visibility purposes, combining this new optical effect to the reflecting material and the fluorescent colours: a simple interlaced image that can flip from fluorescent yellow to orange will attract the attention of drivers more than todayâs safety clothing:   
  
 - when the industrial process and the machine will be ready, there will start the production of different fabrics with lenticular effects for high visibility purposes.   
 - in case of lenticular high visibility is equipped on firemen ppe, also flammability tests accord ...

# LION-TEX

Project Acronym: LION-TEX

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('lenticular', 66)
* ('image', 40)
* ('images', 31)
* ('textiles', 29)
* ('process', 26)
* ('software', 26)
* ('resin', 24)
* ('resins', 20)
* ('textile', 19)
* ('visibility', 17)
* ('layer', 17)
* ('effect', 16)
* ('effects', 16)
* ('ink-jet', 16)
* ('parameters', 16)
* ('order', 15)
* ('shape', 14)
* ('output', 14)
* ('safety', 13)
* ('printer', 13)
* ('number', 13)
* ('project', 12)
* ('printing', 12)
* ('lenses', 12)

executive summary:   
  
 the lion-tex project represents a breakthrough innovation in the field of textile printing. the step forward is represented by the possibility of bringing onto textiles the three-dimensional (3d) effect of lenticular images, and exploiting it for improving the efficiency of high visibility safety garments and devices.   
  
 the lenticular effect is a well-known technology that allows reproducing a few 3d effects on flat surfaces. two or more images are interlaced (i.e. 'cut' into very narrow stripes and put together, alternating one stripes of the first picture and one of the second) and covered with a lenticular layer, that is a transparent sheet, shaped as an array of semi-cylindrical lenses. each semi-cylinder covers exactly the two (or more) interlaced stripes, acting as a magnifying lens: this way, the observer's view is focused on one of the picture, depending on the relative position. when the observer relatively moves respect to the lenticular image, he can see the picture changing.   
  
 the technology developed in the lion-tex project allows to recreate this effect on textiles, with an efficient, cost effective and robust innovative printing machine. the machine is basically composed by a common ink-jet printer for textiles, a dryer, a second printhead for resin dispensing and an ultraviolet (uv)-curing light for freezing the resin. thanks to this innovative machine, the lenticular images (and textiles) production process is a lot simplified:   
  
 - the textile is positioned by the carpet.   
 - the ink-jet printheads print the interlaced image on the surface of the textile.   
 - the ink-dryer passes over the textile and fix the ink on the surface.   
 - the resin dispenser is positioned over the interlaced part and covers the image with an array on lenses.   
 - the uv-curing system freezes the dispensed resin so that it maintains the wanted shape and curvature.   
 - the lenticular textile is ready and the carpet advances for the production of the next portion.   
  
 the overall savings of the new process are a breakthrough. first of all raw materials: the polymeric array of lenses is directly built on the surface, 'on-demand', and so there is no more need for shaping and cutting pre-formed rolls and no more waste produced. the energy needed for forming the lenticular layer is much lower (up to 1:50) than that used for extruding the polymeric film and calander it into the final shape. furthermore, being everything integrated and synchronised in one machine, there is no time needed for fine positioning and combine the printed image and the lenticular layer.   
  
 beside all possible future applications of this new technology, the high visibility effect for safety garments is the one with the highest potential and gain.   
  
 high visibility garments (for example drivers emergency jacket) are commonly made of polyester textile very bright coloured (yellow, orange, green) and some reflective stripes. the lenticular plotter enables the creation of a new generation of safety garments characterised by an enhanced high visibility effect; the jacket, or part of it, is coloured with an interlaced bright image (e.g. green and yellow) and covered with the lenticular layer: all observers, depending on their relative position and movement, will see a colour-changing high visibility jacket, with a 'flashing' effect from green to yellow that will capture much more their eyes. human eyes, in fact, respond quicker to dynamic effect instead of static, so lenticular effect can really enhance the properties of safety garments.   
  
 the project accomplished all its objectives and developed a demonstrator of the lenticular plotter, not ready for commerce yet but able to produce small lots of lenticular textiles and a first prototype of lenticular high-visibility garment.   
  
 project context and objectives:   
  
 the need for safety:   
  
 as stated by the european agency for safety and health at work (osha) and the canadian centre for occupational health and safety (ccohs) , high-visibility safety apparel (hvsa) is essential for people that work when there is low light and poor visibility and, in particular, where the working place involves moving vehicles.   
  
 the human eye responds best to large, contrasting, bright or moving objects: that is why high-visibility items allow people to be seen by drivers sooner and more readily. at the state of the art, worker visibility is enhanced by high colour contrast between clothing and the work environment against which it is seen.   
  
 in order to address this issue and minimise accidents, the european union (eu) directives 89/656/eec and 89/686/eec, which oblige employers to make available high visibility clothes to their employees.   
  
 in europe 16 million workers operate in low-visibility environments, including roadway construction personnel and vehicle operators, utility workers, survey crews, emergency responders, railway workers and accident site investigators, school crossing guards, parking and toll gate personnel, airport ground crews and law enforcement personnel directing traffic, parking service attendants, workers in warehouses with equipment traffic, shopping cart retrievers, sidewalk maintenance workers, and delivery vehicle drivers, to name a few. statistics report that every year 6 000 of them are injured by vehicles or human operated equipment, because of a lack of visibility, especially in night time operations.   
  
 state-of-the-art solutions consist in applying reflective material stripes onto the garment surface. these stripes are made of an open lens type reflective film consisting of high index reflective micro glass beads on a background of fluorescent material. however this passive solution is not effective if we consider that a recent study highlighted that the main cause is the late detection by the driver, since the vehicle lights are not able to illuminate effectively the side of the road. this is in agreement with much anecdotal evidence from the roadside after vehicles have hit pedestrians. after hitting pedestrians at night, many drivers claim that they never saw the pedestrian, often reporting that the impact was the first warning they had of their presence. over the cost in human lives, also the social cost for persons injured has to be taken into account: estimating 10 days hospitalisation and the costs for rehabilitation (the mean costs per inpatient day were eur 230 (range: eur 154 - 311) in general hospitals and eur 323 (range: eur 209 - 400) in university hospitals) , and 30 days inability to work (conservatively eur 60 per day), it is possible to state that, globally, these accidents do account for a cost conservatively, eur 30 million per year related to such accidents.   
  
 therefore, in spite of the norms and the attentions paid in the last 20 years, a lack of security in garments for workers is perceived. this technological gap can be filled thanks to innovative way of thinking the textile substrate. the textiles and clothing industry is one of europe's leading industrial sectors and, in particular, the technical textile industry represents a greater and greater percentage of the total production of western europe countries.   
  
 the need for technical textiles:   
  
 the worldwide consumption of fibres for technical applications was around the 40 % of global consumption, that is 29 million tons on 72.5 million tons with an overall value of usd 130 milliard. the growth foreseen in next decade is of about 2.1 % every year, challenging 89.3 million tons in 2020. in a general panorama of decline for the textiles market (- 25 % from 2000 to 2010), the technical applications have turned out substantially stable (- 5 %, comprehensive of effect crisis).   
  
 the evolution of the technical textiles market for europe is foreseen to be stable in next years, with the production volumes on the levels of the 2008 (cirfs, 2011), equal to approximately 6 % of the worldwide production of technical (approximately usd 7.8 miliard in 2010) (bch, 2011).   
  
 the german market is a good reference to figure out the economic trend of high quality technical textiles in the euro area.   
  
 from 2000 to 2008 (before the crisis) the total textile production has decreased of around 17 %, while the technical textiles production has increased, in the same period, of 22 %. from latest results of 2011, so including the figures of the recent recession, we can say that the production of textiles has suffered an overall decrease of - 25 %, while technical textiles has increased the production of 22 % (data 2001 - 11).   
  
 according to these figures, despite the large volumes of textiles for fashion and apparel are migrating to asian and brazil, russia, india and china (bri)c countries, the production of technical textile remains one of the stronger asset of european manufacturing industry.   
  
 among the other technical textiles, industrial protective clothing market in europe and the united states of america (usa) together share the greatest percentage of the global market. rising emphasis on worker health/safety issues, stricter government mandates, technology innovation, and increasing pressure to reduce costs associated with workplace related injuries led disability and death, will stimulate the world industrial protective clothing market to reach usd 7.7 billion by 2015.   
  
 europe still represents a major producer of technical textiles, supported by the technological gap with emerging countries: that a niche added-value market, european manufacturing system shall maintain inside the boundaries.   
  
 the growth of the need for safety textiles in asia will be driven by new manufacturing works and construction projects underway in middle east, and asia, particularly, india, china, and vietnam. additionally, apart from being the world's most populous countries, china and india have a large number of unprotected industrial workers and this offers a further potential for future growth.   
  
 this can represent an opportunities, for the smes involved in the 3d lion project, to increase the technological gap with emerging countries and increase their competitiveness in such a difficult, but very large, market of safety textiles and garments.   
  
 the project idea:   
  
 the lion-tex project is based on an innovative method of producing lenticular pictures, which allows them to be directly created on non-flat or bendable surfaces like textiles, thus realising lenticular effects even on textiles, by creating a lenticular layer of a transparent resin directly on it.   
  
 a particular printing method is represented by lenticular images, a very well-known technology, exploited in many fields such as photography and postcards, commercials and a great number of gadgets. lenticular images are optical effects created by coupling a digitally treated picture (interlaced picture) and a layer of lenses (lenticular layer); the typical optical effects that can be reproduced are flip, morphing, zoom, 3d and moving effects.   
  
 usually lenticular images consist of two elements: a digitally modified image, which is called 'interlaced picture' and a layer of lenses called 'lenticular sheet', which is produced by extruding a flat layer of plastic which is then thermally deformed by a calandra, in order to assume the shape of the required lens. the interlaced picture is usually printed on a substrate of plastic or paper and the layer of lenses is glued on it; sometimes the interlaced images can even be directly printed on the flat surface of the lenticular substrate. at the state of the art, when lion-tex began, lenticular images were not exploited in textile industry, neither for fashion scope nor for high visibility function. with the current technology, it is rare to find applications on textiles and, in any case, they just consists of a patch, welded or sewed, which is not a fully integrated part of the garment. a lenticular patch can strongly affect the rigidity of fabric with two bad effects: it modifies the wearability of garments and it difficultly exploits the continuous 3d movements and bends of flexible textiles. moreover, the patch cannot recreate a particular shape (a logo, a stripe, a basic shape) without a waste of materials: the lenticular sheets are usually squared and they shall be cut, adjusted and most of them are just thrown as process waste.   
  
 the innovative process consists of 2 fully integrated process steps:   
  
 (a) interlaced image is generated by dedicated software and then printed on the textile with an ink-jet printer;   
 (b) lenticular layer is created with an ink-jet dispenser machine, which is able to treat resins with high viscosity and to build 3d patterns.   
  
 in this way, lenticular layers can be easily created on every material, plastic, paper and textiles, introducing new opportunities of application. the innovative method of creating lenticular printed textiles can be exploited for safety purposes, adding to the common high visibility effects an additional 'flashing' effects that represents an extremely important added value.   
  
 the process is industrialised in a lenticular automatic plotter.   
  
 the very interesting reached results convinced the owner of the idea (and of the previous patent lion-tex is based on) to go for a second patent and secure the concepts and the technologies of the lion-tex lenticular plotter.   
  
 project results:   
  
 in line with the above mentioned needs, lion-tex partners have set-up and performed three key research areas, namely:   
  
 - the software: interlacing software should manage innovative lenticular effects, related to the 3d, bendable surfaces: the shape of lenses should be re-designed and optimised, first of all to adapt them to 3d surfaces and then because of the new optical effects provided by new interlacing software. gathered results: a simpler and user-friendly software has been developed, to generate lenticular images; an innovative software for integrating lenticular images onto image files; an innovative printer rip, that enables the translation of image files (\*.jpeg; \*.bmp; \*.tiff) into a binary file that controls plotter and printheads movements.   
  
 - the process: resins had to be investigated, in order to find the ones possessing the right requirements for this application. the most suitable resin for lenticular effects must be transparent, dispensable by ink-jet printheads and flexible enough to be coupled to fabric substrates without cracking. the largest number of resins tested was uv-curable resins: they should cure as fast as possible and, at the same time, avoid the proclivity to become yellow, as ageing effect. moreover, the normal usage of printed fabric or garments should be investigated, in order to figure out the possible effects on the resin of common operation on textiles like washing or ironing, and avoid any possible related risk. the ink-jet resin dispenser should be integrated into a common ink-jet textile printer, in order to create a demonstration machine which allows at first step to print the interlaced image on the fabric, and then to print on that image the lenticular lenses, without moving the substrate to other machine or process station. this integration allows saving time in the printing process and decreases the need of calibration between the interlaced image and the lenticular sheet. the lenticular layer created by the ink-jet dispenser depends on several machine parameters and it should be optimised, in order to perfectly fit with the interlaced image. gathered results: a set of new resins has been developed and the results of test on textiles demonstrated the feasibility of 3d lenses creation on the surface.   
  
 - the product: the final products, fabrics and clothing, should be tested as described in the reference norms, and grant a higher visibility effect for improving safety in dark low contrast environments. gathered results: several samples of lenticular coated textile have been produced (and are still being produced by vogue). the garment has not yet been tailored, but the consortium is ready to.   
  
 in order to overcome the previously introduced technical barriers, key scientific and technical objectives have been set in each of the three areas, by the consortium: software and control, the lenticular process itself and the high visibility textile.   
  
 as far as the software is concerned, the objectives targeted in the proposal have all been accomplished within the project.   
  
 - management of innovative lenticular effects: at the state of the art, different software can be exploited to create a flat interlaced image, by introducing only few parameters that describe the kind of effect one wants to obtain. the problem related to the lenticular printing on textile is that the software should interlace the images while taking into consideration that the substrate is not flat and it can be bent. the developed software can manage the whole process, from the creation of the interlace picture, to the requirements of lenticular arrays, to the synchronisation of the two printheads. other basic shape interlacement: pictures are 'cut' and joined together along a basic shape required by ppe garments. the software allow to create an interlaced picture and insert it onto a not interlaced background, in order to ink-print the background and create ad-hoc patterns on the interlaced part of the image. thanks to the developed software, the two printheads can be controlled in a synchronised way, for best results.   
  
 definition of patterns: the software can even calculate the optimised patterns (dimensions and parameters of the lenses, geometry of patterns) and send to the ink-jet dispenser the correct information to create the required lenticular sheet.   
  
 - accomplished mission: developing the software we have been concentrated on creation the interlaced images for the cylindrical lens structure because it seems to offer the most promising applications in the textile industry. the software creating the interlaced images will be easily adapted for the other types of lenticular structures. the software allows a user to design an interlaced graphics to work together with lenticular lenses of fitted structure resolution. the lens must be perfectly aligned with the image.   
  
 typical graphics is a composition of two or more interlaced images, which constitute one picture.   
  
 the software is universal and can be used for preparing interlaced images for all mentioned above various lenticular effects.   
  
 in the software, the interlaced image is composed from a few input images. the result depends only on the content of the input images introduced by a user. the software is optimised for a few parameters, which can be selected according to requirements. a user can choose between a few typical printer resolution values (dpi) and different lenticular lens 'resolution' values (lens per inch (lpi)). it is also possible to set the size (in mm) of the output image and the software can control this parameter and required proper dimensions of the input images (in pixels).   
  
 from the relationship dpi to lpi the software calculates the maximum number of images that can be interlaced. a user can chose arbitrarily a number between 2 and the maximum. the number of the input images is the number of 'frames' in the output image. all images are 'bmp' type.   
  
 all parameters described above determine the image pixel dimension. this parameter refers to angle sensitivity of the output image. a user can chose between 1 and the maximum (calculated by the software). the smallest selected number corresponds to the highest angle sensitivity. if the result of multiplication of the image pixel dimension and the number of images is not equal to maximum number of images the software will automatically add a proper number of background pixels. an operator can also select a colour of the background. the interface contains six panels:   
 (1) the printer resolution;   
 (2) the output image dimension;   
 (3) lenticular lens resolution;   
 (4) load images;   
 - image pixel dim;   
 (5) create output image;   
 (6) on the left side and the image display area for loaded bitmaps - on the right.   
  
 the subsequent sections will contain the description of panels functions.   
  
 resolution of the printer: the printer resolution can be selected using the selection list located in the printer resolution panel   
  
 the printer resolution (dpi) is the master parameter. it defines constraints between itself and two other parameters i.e. maximum number of images (maxno in load images panel), maximum dimension of the image pixel (max in image pixel dim panel). these parameters can be also selected by an operator within allowed ranges, otherwise default values are applied. consequently the above parameters modify the output image dimensions given in pixels. all selected values are displayed in create output image panel.   
  
 dimension of the output image: the physical dimension (mm) of the output image can be changed using the edit boxes in the output image dimension panel. the default value is a4 format. any change of the height or width values results in change of dimension values in pixels.   
  
 change of the width of output image in mm (output image dimension panel) from 210 to 420 results in the change of the output image width in pixels and the change to description from 'w4960 pix' to 'w9921 pix'.   
  
 the resolution of the lenticular lens structure can be selected using the list placed in the lenticular lens resolution panel. any modification of lpi affects the value of maximum number of images (the maxno value in the load images panel) and the value of maximum dimension of image pixel (the max value in the image pixel dim panel). if the lenticular lens resolution is not specified by a user program runs with the default value i.e. 40 lpi.   
  
 the software creates two images, starting from two (or several) initial bmp files: the images 'username.bmp' which contains the interlaced image and the 'username\_lenticularlens.bmp' which contains the shape of lenticular structure. both images are saved on a hard disk and are not shown in the main screen of the programme. the software is user friendly. users should set or select the process parameters starting from the top panel and go subsequently to the bottom panel.   
  
 the lens printing parameters should be discussed in the next project stage when the image/lens printer is developed.   
  
 the whole process was initially validated at lab scale, but it still needed efforts to be put at industrial level: in particular it was necessary first to develop the resin(s) and the dispensing device and then to start the integration on a common industrial plotter for textiles.   
  
 many improvements were required on the resins.   
  
 optimisation of basic characteristics:   
  
 the resins needed to create a lenticular sheet must be completely transparent and participate, with their optical behaviour, to the success of the lenticular effects. moreover, since they are going to be dispensed on non-flat textile substrates, the resins shall be soft, in order not to stiffen too much the zone where they are applied and, they shall be bendable, for avoiding the risk of pattern cracking and, at the same time, they should not be absorbed by the fabric during the printing process. thickness of the lenticular layer has to be in the range 0.2 to 1.4 mm, the radius of curvature for the lenses is to be evaluated and designed in accordance to the optical requirements.   
  
 anti-ageing additives: the first products that have been preliminary tested are uv curable resins, since those resins have the great advantage, with respect to other kind of polymers, to cure rapidly. the risk is related to the effect of ageing: uv curable resins are very sensitive, even after the curing phase, to uv radiation and they tend to become yellow or dark because of the exposition to the sun. innovative formulations or additives can avoid or at least slow this ageing process and give to the lenticular printed fabrics a longer life. faster cure process. in the printing process that has been preliminary designed, the uv resins have a two-steps curing phase. every drop of resin ejected by the dispenser is hit by a very concentrated uv spotlight, in order to maintain the required shape, instead of being absorbed by the textile or being smoothed by its own weight. this preliminary curing phase is not enough to completely fix the printed layer, it is necessary a second step tin which the fabric is exposed to a uv radiation source for a longer period. the best suitable resin for lenticular printing shall reduce these phases as much as possible: a 10 mw / cm2 lamp can cure an area of 1 cm2 in about 80 - 100 s, with a high power lamp, 50 - 100 mw / cm2 the same area is cured in 15 - 20 s.   
  
 ink-jet dispensable:   
  
 not all materials are suitable or easy to be treated with ink-jet dispensing systems; these devices require the liquids to be dispensed to grant some physical parameters which should belong to a precise range of values, in order to make the jetting process work. one of the most important parameters is the viscosity of the fluid: since the connecting tubes and mainly the orifice have very small diameters (less than 100 microns) the fluid shall have a viscosity similar to water (1 cps) to be easily treated. if the viscosity of the fluid grows over a certain limit, depending on the geometry of the dispensing device, it is necessary to reduce it, for example with heat. in some difficult cases heat is not enough and chemical additives are necessary to reach that target.   
  
 bendable and suitable for textiles:   
  
 the substrates on which the resins are jetted are not flat: they can be 3d shaped and further more they can be bent. the printed layer, and so the resin, shall follow the fabric in its movements, remaining always tight fitting and avoiding the risk of break. the parameters that shall be studied and optimised were:   
  
 - viscosity of the resin: jetting devices work well when the material to be dispensed has a viscosity in a range of values very close to 1 cps; more viscous materials (up to 100 cps) can be treated by heating them up until their viscosity becomes lower and suitable for jetting.   
 - speed of curing process: in order to create the lenticular layer, the resin is cured in a two-steps process. spot-light freezes the dots of resin on the substrate which maintain the shape until the end of the deposition process and then the whole lenticular layer is cured with a uv lamp. it is important that the curing process is as fast as possible, to avoid the risk of deforming the original shape of the dispensed dots and for speeding the industrial production.   
 - stability to uv radiation: it is the most common contradiction for uv curable resins. uv radiation activates the polymerisation of the resin but, when the curing process is completed, it still has an impact on the resin: uv is the main cause of ageing of resins, which become yellow and opaque.   
 - resistance to normal life cycle of clothing products (washing, drying, folding).   
  
 - accomplished mission: urethane acrylate: we synthesised different resins and three of them were selected and formulated with different reactive diluents:   
  
 (a) resins: (bencryl urethane acrylate a (141).   
 (b) polyether polyol urethane acrylate based on aliphatic di-isocyanate.   
 (c) bencryl urethane acrylate b (137).   
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 as a final result of the project, in which all the improvements are summarised, the dedicated ink-jet dispensing device has been integrated into a common ink-jet printer for fabrics, as a demonstrator, to show how the process can be industrialised.   
  
 the proposed solution foresees the printing phase with the rolling carpet stationary and the two printheads independent from each other, that can move along the print area in the two plan direction one by one. once the print area is completed, the rolling carpet can move forward for a distance equal to the printing area length. this solution eliminates the interdependency and the relative incompatibility between the two printheads.   
  
 version hs-b (high speed) of the plotter allows you to print at high quality with a variable speed from 20 to 40 (m2/h). the lion-tex version also allows to control resining head in order to deposit drops of resin on the basis of the reception of the drawing data and on the reading of the current position of the head itself. via input / output digital signals, the resin deposition phase is handled synchronising the deposition pulses with the actual position of the head and on the basis of design data acquired.   
  
 the lion-tex plotter consists of the following groups:   
  
 (a) axial unwinding with pneumatic brake in controlled pull;   
 (b) braking group;   
 (c) plotter;   
 (d) device for the deposit of resin;   
 (e) rug for fabric transportation;   
 (f) rear heater;   
 (g) cleaning removable device for the carpet;   
 (h) winding system;   
 (i) ink supply system;   
 (j) ink recovery tank.   
  
 the high visibility products:   
  
 the lenticular pictures are potentially interesting for many innovative applications. first of all, from the point of view of protection clothing, the lenticular effect can contribute to high visibility purposes, combining this new optical effect to the reflecting material and the fluorescent colours: a simple interlaced image that can flip from fluorescent yellow to orange will attract the attention of drivers more than todayâs safety clothing:   
  
 - when the industrial process and the machine will be ready, there will start the production of different fabrics with lenticular effects for high visibility purposes.   
 - in case of lenticular high visibility is equipped on firemen ppe, also flammability tests accord ...

# TEMP

Project Acronym: TEMP

programme & topic: FP7-REGPOT REGPOT-2009-2

Most frequent returning words in objectives:

* ('project', 75)
* ('partners', 29)
* ('temp', 26)
* ('cooperation', 25)
* ('management', 23)
* ('cettex', 21)
* ('relevant', 21)
* ('activities', 20)
* ('mobility', 19)
* ('website', 19)
* ('http', 19)
* ('innovation', 17)
* ('region', 16)
* ('research', 16)
* ('knowledge', 16)
* ('results', 15)
* ('online', 15)
* ('technology', 14)
* ('field', 13)
* ('countries', 13)
* ('development', 12)
* ('order', 12)
* ('capacity', 11)
* ('textile', 11)

executive summary:   
  
 the temp project was a capacity building project, towards the strengthening of the technical and scientific competence within the euro-mediterranean (euromed) region in the field of textile technology related topics. the project main goal is to enhance the science and technology (s&t) cooperation in the textile and clothing (t&c) field between portugal, italy and tunisia by reinforcing strategic partnerships in this 3 research entities and 3 innovation promotion associations, namely:   
  
 - citeve: technological centre for the t&c industry of portugal (coordinator),   
 - centre tecnique du textile (cettex),   
 - treviso tecnologia (tvtec),   
 - next technology tecnotessile societa nazionale di ricerca r.l. (next tecnotessile),   
 - the portuguese textile association (atp) and the tunisian innovation and industry promotional agency (apii).   
  
 the project developed an ambitious programme of actions and activities, such as:   
  
 (a) the exchange and mobilisation of human resources between partnering organisations;   
 (b) the knowledge transfer in the field of environmental and energy management;   
 (c) the product and material laboratorial management;   
 (d) intellectual and property right (ipr) and innovation management and product development.   
  
 this knowledge transfer and technical assistance programme was based in the set-up of a very ambitious mobility programme ensuring the exchange of researchers and technical staff between european organisations and the tunisian centre, which is the target of this capacity building project. another relevant activity of the temp project was the definition of specific s&t priorities in partners regions, creating a research agenda and an innovation roadmap specifically designed for the t&c sector within the euromed region. with this euromed innovation roadmap on textiles and clothing, the partners of the temp project would like to contribute to the definition of scientific and technical priorities within the partners' regions, in an integrated way, towards a more effective and positive cooperation. by highlighting research and innovation (r&i) priorities and relevant cooperation topics for the period of 2010 - 2020, in total coherence with the strategic research agenda (sra) defined in other relevant european documents such as the sra of the technological platform for the future of textiles and clothing, the temp project partners believe that a more effective impact and better resource management, can be achieved regarding the particular situation and challenges of the regions involved in the temp project. to ensure an effective dissemination and communication of project results, besides setting up a very strong program of dissemination activities which included more than 15 events (workshops, seminars and conferences) the temp project is highly visible on line, through two different platforms: an institutional project website (see http://www.temp-eumed.eu/ online) and a cooperation facilitator website (see http://www.eumed-gateway.eu/ online for further details).the euromed gateway cooperation platform is a centralised hot spot where you can find all relevant information regarding scientific and technological cooperation within the euromed area.   
  
 the expected impact of these activities will be the following:   
  
 (a) a better integration of european union (eu) and mediterranean (med) countries;   
 (b) the improvement of s&t capacities in the mediterranean partner country (mpc) and convergence region helping the reinforcement of the regional economic and social development;   
 (c) the creation of fruitful and stronger links between partner's organisation and further research and technological development (rtd) organisations in the partnering countries.   
  
 the set-up of a shared services portfolio between partners is also expected to contribute to the economic impact of the project.   
  
 project context and objectives:   
  
 the temp project was a capacity building project towards the strengthening of the technical and scientific competence within the euromed region in the field of textile related topics. the project main goal is to enhance the s&t cooperation in the t&c field between portugal, italy and tunisia by reinforcing strategic partnerships in this 3 research entities and 3 innovation promotion associations, namely:   
  
 - citeve: technological centre for the t&c industry of portugal (coordinator),   
 - centre tecnique du textile (cettex),   
 - treviso tecnologia (tvtec),   
 - next technology tecnotessile societa nazionale di ricerca r.l. (next tecnotessile),   
 - the portuguese textile association (atp) and the tunisian innovation and industry promotional agency (apii).   
  
 the temp project focuses on improving a tighter relationship between italy, portugal and tunisia, in the field of t&c technology, promoting closer cooperation between complementary organisations, namely in the following topics:   
  
 (a) development of scientific and human potential;   
 (b) exchange of know-how and best practices;   
 (c) increase of scientific and technical research capacities.   
  
 this has been achieved through combined actions and activities, such as:   
  
 (1) creating a contact platform with other scientific fields of knowledge or even other industrial sectors (shoe manufacturing, machinery manufacturing) of mutual interest, aiming to improve contacts in all the fashion industry within the partner's countries;   
 (2) exchanging and mobilising of human and material resources between partner's organisations;   
 (3) the knowledge transfer in the field of water management;   
 (4) environmental and energy management; scientific laboratorial analysis and tests;   
 (5) ipr and innovation management and other scientific and technical expertise areas;   
 (6) disseminating scientific information and knowledge as well as the results of s&t research;   
 (7) implementing rtd past project results and best practices in the t&c industry of the med country and convergence region;   
 (8) providing technical assistance and training to enhance knowledge transfer;   
 (9) defining specific scientific and technical priorities in the partners regions, creating a research agenda for the period 2010 - 2015.   
  
 all this activities were combined in a coherent structure based in 7 work packages (wps):   
  
 work platform definition (wp1)   
 - human resources mobility (wp2)   
 - technology and knowledge transfer activities (wp3)   
 - technical assistance activities (wp4)   
 - definition of specific s&t priorities (wp5)   
 - dissemination activities and establishment of the 'contact platform' (wp6)   
 - management and coordination.   
  
 wp1 was mostly about the set-up of a common understanding and vision about the project framework and objectives in order to facilitate all the upcoming tasks and work. most of this activity was related to the proposal review and to the set-up of working groups for each specific technological field addressed by the project, in order for those groups to prepare and develop part of work foreseen in other tasks and to share among them specific technological information.   
  
 wps 2, 3 and 4 were developed in very integrated and complementary way in order to maximise task's results and impact. besides cttex investment in new research and testing equipment mostly within the scope of wp4, the main objective of these wps was the set-up of the mobility program which was the core activity of the project since in order to strength and amplify the competence and capacity building process at cettex. this means staff from cettex (trainees) having training and coached technical assistance sessions in the european project partners' facilities and experts from those european centres conducting coaching and training / knowledge transfer sessions at cettex premises. as mentioned before, the mobility program is also instrumental for wp3 and wp4 objectives, since most of the knowledge and technology transfer and technical assistance foreseen within those wps was achieved through the mobility of human resources between partner institutes.   
  
 the mobility program comprised an integrated training, coaching and technical assistance programme, involving different groups of engineers, technicians and researchers from cettex, organised in 6 different actions and addressing 6 different topics which were set up and provided by different project partners:   
  
 (1) environment and energy (citeve);   
 (2) product and process technologies (next tecnotessile);   
 (3) product design and fashion (tvtec);   
 (4) laboratorial analysis methods and management (citeve);   
 (5) ipr and innovation management (citeve and tvtec);   
 (6) quality and organisational management (citeve and next tecnotessile).   
  
 according to cettex needs and interests, the duration and work load of each action of the mobility program was specifically adapted into two categories:   
  
 - 4 long mobility actions (96 hours each), which was applied to topics 1 - 4. the long mobility actions comprised an integrated program of staff mobility, knowledge transfer and coached technical assistance within those topics according to the methodology bellow and involving the mobility of both cettex staff to european partners premises and european partners staff to cettex premises.   
 - 2 short mobility actions (16 hours each) which was applied to topics 5 and 6, involving only the mobility of european partners' staff to cettex.   
  
 (1) short mobility actions;   
 (2) long mobility actions.   
  
 one important action within wp4 was the investment in research and testing equipment / technology at cettex. the technology implemented by cettex allowed the centre to achieve new research and testing capacity within the field of textile materials, allowing it to better serve the local t&c community. this technology implementation process, was supported and therefore strengthen by the mobility programme action no 4 ('laboratorial analysis methods and management') which was set up in order to specifically match the analytical and methodological testing requirements of the new technologies / equipment installed within the project activities at cettex. the equipment bought and installed within wp4 was:   
 - 1 orbital shaker, 1 boiling bath with shaker, 1 equipment for measurement of water permeability;   
 - 1 equipment to perform the snagging test;   
 - several glass material;   
 - hardware and software to evaluate fabrics dimensional stability according to iso 6330:2012;   
 equipment for sampling and equipment for control of testing devices.   
  
 also within the scope of wp4, despite not foreseen initially, but discussed and accepted with the project officer, cettex has benefit from the partners' technical assistance and knowledge in order to renew and upgrade its institutional website. this upgrade was essential in order for better communicate to the scientific and business community the new competences and capacities resulting from the temp project capacity building activities.   
  
 wp5 aimed at the definition of specific s&t priorities for the development of the t&c sector within the eromed region, identifying topics of common interest for the different partner countries, highlighting r&i priorities and relevant cooperation topics for the period of 2010 - 2020, in total coherence with the sra defined by the european technological platform for the future of textiles and clothing. most of the work performed was based in data collection from existing relevant publications / statistical data, from interviews and meetings with relevant stakeholders in each partner country and also from background knowledge and information available in each partners' organisation. one important deliverable of the project was the definition of a euromed research and development (r&d) and innovation roadmap for the t&c sector. this strategic document was published in english and french language and includes relevant information like a detailed characterisation of the italian, portuguese and tunisian t&c industry, an overview of existent documents and initiatives regarding local and national roadmapping activities, a vision for an euromed region of t&c excellence in r&d and r&i and concludes with the temp project proposal for an r&d and innovation roadmap towards 2020. with this deliverable the partners of the temp project would like to contribute to the definition of scientific and technical priorities within the partners' regions, in an integrated way, towards a more effective and positive cooperation.   
  
 the expected impact of these activities will be the following:   
  
 (a) a better integration of eu and med countries;   
 (b) an improvement in scientific and technical capacities in the mpc and convergence region thus helping the reinforcement of the regional economic and social development;   
 (c) the establishment of strong and effective links between the partner's organisation and other rtd organisations in the partner's countries.   
  
 wp6 included the project dissemination activities, mostly achieved by the organisation and / or attendance in relevant local and international events addressing the target audience (t&c community), through the publication of communication tools (brochures, posters, banners and leaflets) as well as by using two different electronic communication channels: an institutional project website (see http://www.temp-eumed.eu/ online) and a cooperation facilitator website (see http://www.eumed-gateway.eu/ online).the eu-med gateway cooperation platform, another project deliverable, is a centralised hot spot where you can find all relevant information regarding scientific and technological cooperation within the eu-med area regarding t&c business. the temp project was promoted and visible in more than 15 events across the euromed region. still on the dissemination level, concerning synergies with other ongoing platforms and projects, a relevant aspect was the interaction with other 3 ongoing projects within the so called waste cluster initiative (wci), that brought together different projects with common interest in water and waste management, contributing therefore to less overlapping and better integration between activities and strategies under development in ongoing funded european projects. also important was the poster exhibition at the annual conference of the european textile technology platform.   
  
 wp7 exclusively addressed management activities in order to ensure good project development and good communication among partners. in order to facilitate the communication between partners and document / data management, an internal project management web based tool (temp workspace) was adopted and used for project management. all project files, agendas, minutes, documents, publications, contacts and images were stored within this platform, which was available via project website, making therefore very easy to share relevant information between partners. the consortium met for 7 times, at least one time in each partner country and all project partners' have always attend the meetings.   
  
 project results:   
  
 the fact of the temp project of being a coordination action project following a capacity building approach gives to the exploitation of results a different dimension and perspective. in this sense, there are no research results to exploit and no patents or designs to license as scientific or technological results.   
  
 potential impact:   
  
 project potential impacts   
  
 the t&c industry has the necessary potential to set a model and example of re-enforced cooperation between the countries of the med area, that is not limited by geography but also to a number of other countries that for historical or cultural reasons or even economic circumstances constitute a large med region. this region is fundamental to maintain peace, security and economic prosperity to hundreds of thousands of individuals, and assume itself as a geo-political and geo-economic core, that is capable to compete with other controls of power and business in the world today. without using the usual rhetoric and bureaucracy that are usually imposed to deal with such issues and which most of the times stay as good intentions and keep inertia, it is certain that one can structure a vision for the euromed t&c. based on one hand by a common rich and diversified past which modelled nations and the world, with the aim of cooperation by innovation, either by r&d or less technological. no less important is creativeness, where design fashion and more efficient design processes are the best examples.   
  
 in effect, this cooperative vision for the euromed region that temp tried to systematise and even accomplish for the t&c aims at the implementation of a set of objectives that structure and interact.   
  
 so, more than presenting itself as a goal of commercial policies of the eu, to make the southern countries of the med the first option for the supply of t&c it is necessary to share know-how and resources. the balance between cost and quality, geographic and cultural proximity conditions positively service and liability. but when you look for suppliers in further away geographies, this cannot be attained, as recent history has shown.   
  
 by creating a cooperative option in the euromed region, one is acting intensely for the growth of trade at all levels of the value chain and is promoting producers and traders but also the consumer that this way can access to products and services of higher added value. price is still an important issue for the consumer but special emphasis is given to the satisfaction of needs on a sophisticated value point of view. this is easier acknowledged in the southern european countries and by their retail models, which have conquered large shares of consumption all over the world.   
  
 to work in cooperation, to transfer knowledge and experience from both parts also determines product / service added value in the euromed region. this way, new arguments are gathered against world competition, for low price, mass production and non-differentiation are confined to certain consumption segments, which eventually are not interesting to the med t&c chain. therefore is expected that tunisian small and medium-sized enterprises (smes) directly and indirectly benefiting from the capacity building approach promoted by the project on a technology transfer and research organisation like cettex, will be better prepared to enhance a stronger cooperation with european companies, towards the exploitation of new markets.   
  
 besides one must look upon cooperation not as a one way flux, or with rigidly defined fluxes, for which europe relocated production or orders to south, being a consumption market looking for products of relatively low price products, without any other ambition but to develop classic production activities, without sophistication and no evolving in the value chain. control and profit for this type of production lay in the hands of those who relocated production and little to the land where it was relocated.   
  
 one of the interesting outputs of the temp project was the agreement to provide in the future a joint service offer between cettex and the different european r&d centres participating in the project. is expected, for this strategy to have a long last effect in the project dynamic, by creating a clear understanding towards the extension of the cooperation but in this case addressing specific company needs which can be better solved by an integrated service portfolio. in fact, also as a relevant impact, a core group of the temp project partners already submitted a proposal to the seventh framework programme (fp7) international cooperation (inco) programme under the acronym fashiomed, coordinated by tvtec and aiming to empower the temp experience to other mpc partners. fortunately today many of the med-region countries are already collecting the fruits of their investments, by originating emerging appealing consumer markets with segments of society of resources, education, cosmopolitanism and sophistication in taste. it is fair to believe that the temp project experience and outputs will also have a positive impact in this process, since it has demonstrated the importance of staff mobility between organisations in the consolidation of knowledge transfer and cooperation processes.   
  
 finally, the euromed region shares concern for sustainability, whether it is environmental, social and even economic. not diminishing historical differences and the evolution experienced by the different countries, giving special but asymmetrical attention to these issues, they all share the desire for a more balanced space, capable of satisfying their population needs and that, legitimately want the best for themselves and mostly their future generations. once more by addressing topics like environmental management or energy management, the temp project will certainly have an impact in the leverage of the mpc companies towards european standards and practices regarding sustainable production. as an example, the joint service portfolio offered by cettex and citeve in the field of environmental and energy audits, as an output from the temp project, will contribute for local companies to better deal with such relevant competitive factors. the cooperation set up by the temp project between organisations supporting industrial smes and the 'facilitator' tools such as the gateway website; will certainly impact in the relations between european and mpc companies in the future. the last dissemination event in which the temp project consortium participated was the cat 2012 - business and technology convention, in tunisia. at this event the project partners, besides sharing the project booth at the exhibition area, presented their joint offer portfolio within the brokerage event. this approach can be considered as a relevant positive impact of the project, in what concerns the level of cooperation and common trust between organisations towards new upcoming challenges.   
  
 more relation, more business, more scientific interchange, more common work made with projects like temp are an unequivocal certainty that the construction of the euromed region is more than a political utopia but rather an irreversible process of development for the building of a better common future for everyone involved.   
  
 main dissemination activities:   
  
 project dissemination activities, mostly achieved by the organisation and / or attendance in relevant local and international events addressing the target audience (t&c community), through the publication of communication tools (brochures, posters, banners and leaflets) as well as by using two different electronic communication channels: an institutional project website (see http://www.temp-eumed.eu/ online) and a cooperation facilitator website (http://www.eumed-gateway.eu/). also relevant within communication and dissemination activities were contacts, networking and synergies developed with other ongoing initiatives. this was particularly the objective of task 6.3 within wp6, namely to establish synergies with other ongoing platforms and projects.   
  
 the temp project strengthened links with some international initiatives related to t&c, r&d and smes investment and opportunities:   
  
 - anima investment network (see http://www.animaweb.org/en/index.php online for further details),   
 - invest in med (see http://www.invest-in-med.eu/ online for further details),   
 - emdc - promos milano (see euro-med development center for msmes online for further details),   
 - insme (international network for smes, see http://www.insme.org/ online for further details),   
 - pã´le de compã©titvitã© monastir-el fejja (which coordinates a directory of technical textiles tunisian companies, see http://www.mfcpole.com.tn online for further details),   
 - textile 2020, advanced technical textile cluster (see http://textile2020.eu/ online for further details),   
 - industrial council for technology and innovation (egypt),   
 - uptex - competitiveness cluster (see http://www.up-tex.fr online for further details),   
 - programme d'appui ã  la competitivitã© des enterprises et ã  la facilitation del l'accã¨s au marchã¨ (pcam)?(see www.pcam.gov.tn online for further details),   
 - 'network in solid waste and water treatment between europe and mediterranean countries' (sowaeumed) project (http://grupsderecerca.uab.cat/sowaeumed),   
 - 'sustainable innovations and treatment in industrial waste water clusters' (stinno) (see http://www.kalmar.regionforbund.se/stinno/ online for further details),   
 - 'waste management focusing on: knowledge and integration to create transnational economic development' (wastekit) project (see http://www.wastekit.eu/ online for further details).   
  
 within the official project website http://www.temp-eumed.eu, namely in the 'news' area and within the eumed gateway website (http://www.eumed-gateway.eu/) is possible to find more information and pictures and about the dissemination activities of the project.   
  
 exploitation of results   
  
 the fact of the temp project of being a coordination action project following a capacity building approach gives to the exploitation of results a different dimension and perspective. in this sense, there are no research results to exploit and no patents or designs to license, but there are project results which can be further exploited in the future in order to extend the project effect creating conditions to positively 'contaminate' other stakeholders. in fact, one of the main results of the project which corresponds to one of its main proposed objectives is the cooperation linkage, the confidence and trust level which the project has been able to build among all the participating organisations, which certainly has a positive demonstration effect on different stakeholders. this will certainly be exploited in the upcoming future by all the partners in order to develop new partnerships and new joint initiatives which should be of common interest, and not only for each organisation and also for the stakeholders which are directly or indirectly related to the different project partners. regarding specific concrete results of the projects, the following table shows the exploitation potential and strategy to be followed in each case.   
  
 project result / outputs   
  
 (1) improved cettex technological capacity in the field of textiles material r&d and testing:   
 (a) improved r&d and testing portfolio offered to tunisian companies and other relevant local stakeholders;   
 (b) develop new services and projects addressing the tunisian t&c companies.   
 (2) improved cettex technological capacity in the field of environmental and energy management, product design, ipr and innovation management:   
 (a) improved service portfolio offered to tunisian companies and other relevant local stakeholders;   
 (b) develop new services and projects addressing the tunisian t&c companies.   
  
 euromed innovation roadmap on textiles and clothing: this strategic publication will be used by all partners in policy advising work, with local and national public organisations and relevant stakeholders, having responsibilities in the r&d and innovation public policy design. as well as a supporting guideline within new r&d projects consortia building within the euromed area.   
  
 eumed gateway website: the eumed gateway website is one of the powerful results of the project which has a strong exploitation potential. the eumed gateway website will be exploited by treviso tecnologia (tvtec) which will maintain the website hosting and all the website management work. all partners will also contribute with providing tvtec with relevant information and inputs to feed the website.   
  
 joint service portfolio: cettex will use the joint service portfolio developed with each of the project partners, in order to market this integrated offer in the different fields of knowledge to potential clients. with this strategy cettex will enlarge its competence portfolio by combining its own competences with the ones available at citeve, tvtec or next tecnotessile depending on the technical field.   
  
 mobility programme methodology: the methodology of the mobility programme will be exploited by all european partners in further exchange programmes which might be developed with other med partners.   
  
 list of websites: official project website: http://www.temp-eumed.eu/   
 eumed gateway website: http://www.eumed-gateway.eu

# PASSAGE

Project Acronym: PASSAGE

programme & topic: FP7-SME SME-2

Most frequent returning words in objectives:

* ('know-how', 82)
* ('passage', 37)
* ('position', 25)
* ('associations', 22)
* ('profiles', 21)
* ('target', 18)
* ('description', 16)
* ('step', 15)
* ('described', 15)
* ('smes', 14)
* ('guides', 14)
* ('knowledge', 14)
* ('pack', 14)
* ('platform', 13)
* ('tools', 13)
* ('managers', 13)
* ('textile', 12)
* ('management', 12)
* ('tool', 12)
* ('company', 12)
* ('person', 12)
* ('clothing', 11)
* ('courseware', 11)
* ('level', 11)

the passage project, lead by texclubtec italy (it) and four other small and medium sized enterprises (smes) associations in textile and clothing, namely omi france (fr), sepee greece (gr), apm romania (ro) and cci of vratsa bulgaria (bg) has worked from december 2008 to november 2011 to develop an integrated solution, based on an online platform to provide to smes guides, tools and methods to identify their know-how, assess its importance, preserve it and valorise it in different ways, in the framework of a more global preventive management of their hrs.   
  
 the development of the platform and the solutions of passage has been sub-contracted to a team of 5 technical partners, lead by ifth (fr) and comprising atc (gr), clotefi (gr), soltec (it) and raliant (ro).   
  
 to test the solutions four smes have participated to the project: textile du maine (fr), filatura marchi (it), nota (gr) and miraje (bg).   
  
 the results of the project are grouped within a multilingual passage online platform, also called capacity building platform (cbp), on one site (see http://www.passage-know-how.eu online), which offers the following tools and functionalities:   
  
 1. a strategic auto-diagnostic tool for facilitating the expression of the sme business strategy and the identification of jobs affected by it;   
 2. a know-how assessment tool for assessing the importance of the know-how detained by the job positions in the company;   
 3. a documented job profiles database for informing on specific features of jobs under pressure on a given branch of activity, facilitating existing and target job position descriptions (through the use of a 'profiling tool'), including information on existing know-how for activities performed by these job positions;   
 4. a know-how experts identification matrix for identifying who in a job position detains the best knowledge of know-how and to forecast how long (s)he will remain in the company (forecasted retirement or departure) for planning his/her replacement and the preservation of his/her know-how;   
 5. a know-how capture toolkit, composed of guides, courseware, a database and an interface offering a set of functions to document, online or offline, in a safe (protected access and fully manageable rules for sharing or not any part of the documentation stored), structured and re-exploitable way any existing know-how;   
 6. tools to easily and rapidly extract selected parts of know-how documentation for producing easily guides or promotional materials based on it, courses or courseware, or instructions to a sub-contractor on how to proceed to produce a specific order;   
 7. examples of guides, promotional materials, courseware and enriched with know-how technical sheets;   
 8. questionnaires to assess the capacity of sub-contractor to perform an order, taking into account their level of know-how for the targeted production.   
  
 the passage partners intend to offer the passage solution in four packs, in priority to the associations members, but beyond that to any interested association of smes (of textile and clothing - but not exclusively), as well as to bigger organisations who detain know-how and may be interested to find solutions to preserve and valorise it. the proposed packs are:   
  
 1. an introductory self-diagnostics pack for sme-managers;   
 2. a human resource (hr) management pack for hr managers;   
 3. a know-how management pack mainly for consultants, but also for hr managers, production managers, trainers and marketing and sales managers;   
 4. a know-how valorisation pack, offered as complement of the above and including examples of guides, promotional materials, courseware and enriched with know-how technical sheets; questionnaires to assess the capacity of sub-contractors to perform an order, taking into account their level of know-how for the targeted production.   
  
 project context and objectives:   
  
 the objectives of passage are to support industrial smes in better preserving and managing core industrial knowledge and enhancing their competitive position based on a better capitalisation of knowledge-based advantages.   
  
 passage offers answers to four acute problems that smes encounter in hr management:   
  
 1. losses of critical industrial know-how due caused by workforce attrition, due not only to ageing population (retirement) but also to downsizing and restructuring, linked to the process of migration of production capacities to low wage labour countries;   
 2. needs of acquiring know-how for mastering new techniques, processes, linked to increased speeds of innovation in any domain;   
 3. needs to improve their know-how each day to remain competitive;   
 4. needs to transfer know-how they have to their partners, due to the development of a widely distributed working processes (externalisation of tasks, sub-contracting, enrichment of services to clients with knowledge).   
  
 for this, the passage project developed a web-based 'capability nanagement platform', providing industrial associations and their affiliated smes with on-line tools to assess risks of know-how loss, capture, preserve and transfer the existing key industrial expertise and forecast emerging competencies of strategic interest, taking into account the technological evolution and the industrial context.   
  
 why is this initiative critical?   
  
 in particular, for the next five to seven years, maintaining a professional, skilled and qualified labour force will be a major issue in thousands of european businesses.   
  
 in fact, paralleling the steady aging of the population and the associated retirement wave, some other troubling facts are emerging, such as a growing migration of workers from their country of origin to a higher wage country or lowering investments in manufacturing and research in highly industrialised regions.   
  
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 4. a strategic auto-diagnostic tool for facilitating the expression of the sme business strategy and the identification of jobs affected by it - described in d3 as d3.2;   
 5. the passage anticipation matrix (or know-how experts identification matrix), which is described in d4 as d4.1; in the form of an excel sheet it allows to identify the tasks or operations that must be analysed before processing a preservation of know-how, the players likely to transfer know-how on an activity or a given operation (know-how experts) and internally, if this is the choice of the company, people eligible for the transfer of skills;   
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 4. define a target job position related to n1 existing job profiles (reference job profiles or enterprise job profiles);   
 5. resulting 'full target job position description' is created by merging the information of each cell the n1 job profiles declared;   
 6. revise this 'full target job position description' to describe in each field the specific information concerning the targeted job position and create a 'full job targeted position description of person x';   
 7. select the fields to match between 'full existing job position description of person x' and 'full job targeted position description of person x' (e.g. skills, activities and/or know-how);   
 8. obtain a grid with for each field of the full job position description (which will have the same structure as the current job profiles description but will refer to more than one job profile), i.e. on the left the 'full existing job position description of person x'; on its middle the 'full job targeted position description of person x'; on the right the 'decisions' taken to bridge the displayed gaps; on the extreme right the level of difficulty to implement the decision and the importance of implementing the decision (priority level); on the extreme right: possibility to assess the level of difficulty to implement the decision;   
 9. fill decisions, difficulty and importance columns and establish a 'plan of evolution of competences of person x';   
 10. communicate using this plan with training organisations, hr management experts and the person x and implement the decisions taken;   
 11. use the field 'know-how' to collect all documentation existing on a missing and needed know-how which is on passage and provide it either to a training organisation or directly to person x.   
  
 the packs which will be proposed - targets - exploitation plans:   
  
 the passage partners intend to offer the passage solution in four packs:   
  
 1. an introductory self-diagnostics pack for sme-managers including the strategic auto-diagnostic tool the know-how assessment tool. the pack will be offered directly, after a trial use with a consultant, or through sme associations or consultants, to the target users at a price for final users of eur 150 per year. first target will be the members of the associations involved in passage, at a second step associations in textile and clothing of the participating countries, at a third step associations in textile and clothing in other countries in euromed, at a fourth step associations of smes of other industry sectors. annual revenues of exploiting this pack are evaluated at eur 155 000.   
 2. a hr management pack for hr managers, including the know-how assessment tool; the documented job profiles database for informing on specific features of jobs under pressure on a given branch of activity, facilitating existing and target job position descriptions (through the use of a 'profiling tool'), including information on existing know-how for activities performed by these job positions; the know-how experts identification matrix for identifying who in a job position detains the best knowledge of know-how. the pack will be offered directly, after a trial use with a consultant, or through sme associations or consultants, to the target users at a price for final users of eur 600 per year. first target will be the big smes and bigger companies members of the associations involved in passage, at a second step associations in textile and clothing of the participating countries, at a third step associations in textile and clothing in other countries in euromed, at a fourth step associations of other sectors (including non industrial sectors - as for instance public administrations could be also interested). potential annual revenues of exploiting this pack are estimated at more than eur 300 000   
 3. a know-how management pack mainly for consultants, but also for hr managers, production managers, trainers and marketing and sales managers including the know-how experts identification matrix; the know-how capture toolkit, composed of guides, courseware, a database and an interface offering a set of functions to document, online or offline, in a safe (protected access and fully manageable rules for sharing or not any part of the documentation stored), structured and re-exploitable way any existing know-how; tools to easily and rapidly extract selected parts of know-how documentation for producing easily guides or promotional materials based on it, courses or courseware, or instructions to a sub-contractor on how to proceed to produce a specific order   
 4. a know-how valorisation pack, offered as complement of the above and including examples of guides, promotional materials, courseware and enriched with know-how technical sheets; questionnaires to assess the capacity of sub-contractor to perform an order, taking into account their level of know-how for the targeted production. the pack will be offered directly, after a trial use with a consultant, or through sme associations or consultants, to the target users at a price for final users of eur 750 per year. first target will be the companies members of the associations involved in passage, at a second step associations in textile and clothing of the participating countries, at a third step associations in textile and clothing in other countries in euromed, at a fourth step associations of other sectors (including non industrial sectors - as for instance public administrations could be also interested). potential annual revenues of exploiting this pack are estimated at more than eur 400 000.   
  
 that means that more than eur 750 000 could be shared between the five involved sme associations (average eur 150 000 of revenues for each of them), while prices for final users will be very attractive for those (other associations and consultants) who will be involved in the distribution of this solution.   
  
 that's why at least two associations belonging to the consortium intend to exploit these results: texclubtec and omi.   
  
 as texclubtec is interested in the financial exploitation after the project, there are two options of a business model: the first option is the direct selling only the product (mainly to large-scale enterprises and public institutions); the second option is to sell also the associated service to support the users in better managing the tools of the 'capability management platform' (mainly to smes).   
  
 a crucial point concerning this topic constitutes the ability to initiate new projects with regard to the gained competences in the field of hr management. specifically, an exploitation of passage, relating preserving and managing industrial knowledge, is already been included in a cooperation agreement with confindustria como (industrial association with 250 companies) to support projects of industrial reorganisation from the side of preserving and managing core industrial knowledge.   
  
 beyond the project lifetime, omi will exploit not only the web-services but also the on the field support to its sme members. more specifically, omi will propose that the strategic diagnosis could be used by forthac consultants and ifth transfer engineers. updating of risks, opportunities and projects, resulting from previous users experience will enrich it. smes will get out of it identification of actions needed to put in place to manage their skills strategy (anticipation and recruitment support, training, technological assistance etc.).   
  
 omi, with the support of ifth and forthac collaboration, will develop a 'labellised training programme dedicated to experts, on the identification / preservation / transfer of critical and strategic know-how'.   
  
 list of websites:   
 - http://www.passage-project.eu   
 - http://www.passage-know-how.eu

# PASSAGE

Project Acronym: PASSAGE

programme & topic: FP7-SME SME-2

Most frequent returning words in objectives:

* ('know-how', 82)
* ('passage', 37)
* ('position', 25)
* ('associations', 22)
* ('profiles', 21)
* ('target', 18)
* ('description', 16)
* ('step', 15)
* ('described', 15)
* ('smes', 14)
* ('guides', 14)
* ('knowledge', 14)
* ('pack', 14)
* ('platform', 13)
* ('tools', 13)
* ('managers', 13)
* ('textile', 12)
* ('management', 12)
* ('tool', 12)
* ('company', 12)
* ('person', 12)
* ('clothing', 11)
* ('courseware', 11)
* ('level', 11)

the passage project, lead by texclubtec italy (it) and four other small and medium sized enterprises (smes) associations in textile and clothing, namely omi france (fr), sepee greece (gr), apm romania (ro) and cci of vratsa bulgaria (bg) has worked from december 2008 to november 2011 to develop an integrated solution, based on an online platform to provide to smes guides, tools and methods to identify their know-how, assess its importance, preserve it and valorise it in different ways, in the framework of a more global preventive management of their hrs.   
  
 the development of the platform and the solutions of passage has been sub-contracted to a team of 5 technical partners, lead by ifth (fr) and comprising atc (gr), clotefi (gr), soltec (it) and raliant (ro).   
  
 to test the solutions four smes have participated to the project: textile du maine (fr), filatura marchi (it), nota (gr) and miraje (bg).   
  
 the results of the project are grouped within a multilingual passage online platform, also called capacity building platform (cbp), on one site (see http://www.passage-know-how.eu online), which offers the following tools and functionalities:   
  
 1. a strategic auto-diagnostic tool for facilitating the expression of the sme business strategy and the identification of jobs affected by it;   
 2. a know-how assessment tool for assessing the importance of the know-how detained by the job positions in the company;   
 3. a documented job profiles database for informing on specific features of jobs under pressure on a given branch of activity, facilitating existing and target job position descriptions (through the use of a 'profiling tool'), including information on existing know-how for activities performed by these job positions;   
 4. a know-how experts identification matrix for identifying who in a job position detains the best knowledge of know-how and to forecast how long (s)he will remain in the company (forecasted retirement or departure) for planning his/her replacement and the preservation of his/her know-how;   
 5. a know-how capture toolkit, composed of guides, courseware, a database and an interface offering a set of functions to document, online or offline, in a safe (protected access and fully manageable rules for sharing or not any part of the documentation stored), structured and re-exploitable way any existing know-how;   
 6. tools to easily and rapidly extract selected parts of know-how documentation for producing easily guides or promotional materials based on it, courses or courseware, or instructions to a sub-contractor on how to proceed to produce a specific order;   
 7. examples of guides, promotional materials, courseware and enriched with know-how technical sheets;   
 8. questionnaires to assess the capacity of sub-contractor to perform an order, taking into account their level of know-how for the targeted production.   
  
 the passage partners intend to offer the passage solution in four packs, in priority to the associations members, but beyond that to any interested association of smes (of textile and clothing - but not exclusively), as well as to bigger organisations who detain know-how and may be interested to find solutions to preserve and valorise it. the proposed packs are:   
  
 1. an introductory self-diagnostics pack for sme-managers;   
 2. a human resource (hr) management pack for hr managers;   
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 project context and objectives:   
  
 the objectives of passage are to support industrial smes in better preserving and managing core industrial knowledge and enhancing their competitive position based on a better capitalisation of knowledge-based advantages.   
  
 passage offers answers to four acute problems that smes encounter in hr management:   
  
 1. losses of critical industrial know-how due caused by workforce attrition, due not only to ageing population (retirement) but also to downsizing and restructuring, linked to the process of migration of production capacities to low wage labour countries;   
 2. needs of acquiring know-how for mastering new techniques, processes, linked to increased speeds of innovation in any domain;   
 3. needs to improve their know-how each day to remain competitive;   
 4. needs to transfer know-how they have to their partners, due to the development of a widely distributed working processes (externalisation of tasks, sub-contracting, enrichment of services to clients with knowledge).   
  
 for this, the passage project developed a web-based 'capability nanagement platform', providing industrial associations and their affiliated smes with on-line tools to assess risks of know-how loss, capture, preserve and transfer the existing key industrial expertise and forecast emerging competencies of strategic interest, taking into account the technological evolution and the industrial context.   
  
 why is this initiative critical?   
  
 in particular, for the next five to seven years, maintaining a professional, skilled and qualified labour force will be a major issue in thousands of european businesses.   
  
 in fact, paralleling the steady aging of the population and the associated retirement wave, some other troubling facts are emerging, such as a growing migration of workers from their country of origin to a higher wage country or lowering investments in manufacturing and research in highly industrialised regions.   
  
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 4. define a target job position related to n1 existing job profiles (reference job profiles or enterprise job profiles);   
 5. resulting 'full target job position description' is created by merging the information of each cell the n1 job profiles declared;   
 6. revise this 'full target job position description' to describe in each field the specific information concerning the targeted job position and create a 'full job targeted position description of person x';   
 7. select the fields to match between 'full existing job position description of person x' and 'full job targeted position description of person x' (e.g. skills, activities and/or know-how);   
 8. obtain a grid with for each field of the full job position description (which will have the same structure as the current job profiles description but will refer to more than one job profile), i.e. on the left the 'full existing job position description of person x'; on its middle the 'full job targeted position description of person x'; on the right the 'decisions' taken to bridge the displayed gaps; on the extreme right the level of difficulty to implement the decision and the importance of implementing the decision (priority level); on the extreme right: possibility to assess the level of difficulty to implement the decision;   
 9. fill decisions, difficulty and importance columns and establish a 'plan of evolution of competences of person x';   
 10. communicate using this plan with training organisations, hr management experts and the person x and implement the decisions taken;   
 11. use the field 'know-how' to collect all documentation existing on a missing and needed know-how which is on passage and provide it either to a training organisation or directly to person x.   
  
 the packs which will be proposed - targets - exploitation plans:   
  
 the passage partners intend to offer the passage solution in four packs:   
  
 1. an introductory self-diagnostics pack for sme-managers including the strategic auto-diagnostic tool the know-how assessment tool. the pack will be offered directly, after a trial use with a consultant, or through sme associations or consultants, to the target users at a price for final users of eur 150 per year. first target will be the members of the associations involved in passage, at a second step associations in textile and clothing of the participating countries, at a third step associations in textile and clothing in other countries in euromed, at a fourth step associations of smes of other industry sectors. annual revenues of exploiting this pack are evaluated at eur 155 000.   
 2. a hr management pack for hr managers, including the know-how assessment tool; the documented job profiles database for informing on specific features of jobs under pressure on a given branch of activity, facilitating existing and target job position descriptions (through the use of a 'profiling tool'), including information on existing know-how for activities performed by these job positions; the know-how experts identification matrix for identifying who in a job position detains the best knowledge of know-how. the pack will be offered directly, after a trial use with a consultant, or through sme associations or consultants, to the target users at a price for final users of eur 600 per year. first target will be the big smes and bigger companies members of the associations involved in passage, at a second step associations in textile and clothing of the participating countries, at a third step associations in textile and clothing in other countries in euromed, at a fourth step associations of other sectors (including non industrial sectors - as for instance public administrations could be also interested). potential annual revenues of exploiting this pack are estimated at more than eur 300 000   
 3. a know-how management pack mainly for consultants, but also for hr managers, production managers, trainers and marketing and sales managers including the know-how experts identification matrix; the know-how capture toolkit, composed of guides, courseware, a database and an interface offering a set of functions to document, online or offline, in a safe (protected access and fully manageable rules for sharing or not any part of the documentation stored), structured and re-exploitable way any existing know-how; tools to easily and rapidly extract selected parts of know-how documentation for producing easily guides or promotional materials based on it, courses or courseware, or instructions to a sub-contractor on how to proceed to produce a specific order   
 4. a know-how valorisation pack, offered as complement of the above and including examples of guides, promotional materials, courseware and enriched with know-how technical sheets; questionnaires to assess the capacity of sub-contractor to perform an order, taking into account their level of know-how for the targeted production. the pack will be offered directly, after a trial use with a consultant, or through sme associations or consultants, to the target users at a price for final users of eur 750 per year. first target will be the companies members of the associations involved in passage, at a second step associations in textile and clothing of the participating countries, at a third step associations in textile and clothing in other countries in euromed, at a fourth step associations of other sectors (including non industrial sectors - as for instance public administrations could be also interested). potential annual revenues of exploiting this pack are estimated at more than eur 400 000.   
  
 that means that more than eur 750 000 could be shared between the five involved sme associations (average eur 150 000 of revenues for each of them), while prices for final users will be very attractive for those (other associations and consultants) who will be involved in the distribution of this solution.   
  
 that's why at least two associations belonging to the consortium intend to exploit these results: texclubtec and omi.   
  
 as texclubtec is interested in the financial exploitation after the project, there are two options of a business model: the first option is the direct selling only the product (mainly to large-scale enterprises and public institutions); the second option is to sell also the associated service to support the users in better managing the tools of the 'capability management platform' (mainly to smes).   
  
 a crucial point concerning this topic constitutes the ability to initiate new projects with regard to the gained competences in the field of hr management. specifically, an exploitation of passage, relating preserving and managing industrial knowledge, is already been included in a cooperation agreement with confindustria como (industrial association with 250 companies) to support projects of industrial reorganisation from the side of preserving and managing core industrial knowledge.   
  
 beyond the project lifetime, omi will exploit not only the web-services but also the on the field support to its sme members. more specifically, omi will propose that the strategic diagnosis could be used by forthac consultants and ifth transfer engineers. updating of risks, opportunities and projects, resulting from previous users experience will enrich it. smes will get out of it identification of actions needed to put in place to manage their skills strategy (anticipation and recruitment support, training, technological assistance etc.).   
  
 omi, with the support of ifth and forthac collaboration, will develop a 'labellised training programme dedicated to experts, on the identification / preservation / transfer of critical and strategic know-how'.   
  
 list of websites:   
 - http://www.passage-project.eu   
 - http://www.passage-know-how.eu

# NU-WAVE

Project Acronym: NU-WAVE

programme & topic: FP7-SME SME-2

Most frequent returning words in objectives:

* ('textile', 45)
* ('machines', 35)
* ('machine', 30)
* ('parts', 22)
* ('system', 17)
* ('yarn', 16)
* ('weft', 15)
* ('analysis', 14)
* ('design', 14)
* ('demonstrator', 14)
* ('surface', 14)
* ('order', 13)
* ('production', 12)
* ('wear', 12)
* ('part', 12)
* ('materials', 11)
* ('reduction', 11)
* ('bath', 11)
* ('technology', 10)
* ('development', 10)
* ('energy', 10)
* ('resistance', 10)
* ('bars', 10)
* ('project', 9)

executive summary:  
  
although europe keeps the world-wide leadership in the textile market, far east has become a major manufacturing area. this situation opened new perspectives in fast growing markets for the european manufacturers of textile machines, 95% of which are small and medium-sized entreprises (sme)s. however, as today textile machines mainly consist of established electro-mechanical systems the advantages were only of short duration. an intensive effort of the manufacturers of textile machines in asian countries in introducing the production of cheaper textile machines comparable in output but incomparable in price has started. as a result, far-east has become the first applicant in the world as far as the number of patents on new machines and equipment for textile manufacturing is concerned, almost filling the gap with europe.   
  
project context and objectives:  
  
the textile sector has an annual turnover of more than 200 billion euros and employs some 2.5 million people in over 150,000 smes across the eu-27. although europe keeps the world-wide leadership in the market, far east has become a major manufacturing area. this situation opened new perspectives in fast growing markets for the european manufacturers of textile machines, 95% of which are smes, representing an annual turnover of more than 12 billion euros and providing jobs to some 100,000 employees. germany and italy as the main two producers of textile machines benefited most reaching respectively 3.8 and 2.7 billion euro turnover. furthermore new member states as the czech republic, pioneer of many of the innovations of the last century as air jet looms and automatic circular knitting technology had large opportunities. however, as today textile machines mainly consist of established electro-mechanical systems which are used to create a yarn or filament, interlacing them during weaving or knitting and transport the fabrics for further finishing, the advantages were only of short duration. an intensive effort of the manufacturers of textile machines in asian countries in introducing the production of cheaper textile machines comparable in output but incomparable in price has started. as a result, far-east has become the first applicant in the world as far as the number of patents on new machines and equipment for textile manufacturing is concerned, almost filling the gap with europe. patent and brand infringement is also a key issue due to the highly traditional technological approaches so far used in textile machines which are easily copied. this represents a major threat for european textile machinery smes, their competitiveness and knowledge base.  
  
the only way forward for european manufactures of textile machines and producers of textiles and textile products is to establish once again the long tradition of symbiotic cooperation between the two sectors and to innovative products and product portfolio, searching for new sophisticated solutions in high added value markets. european firms have a high competitive advantage when developing new textile products and machines for their production. to solve the tasks connected with ensuring the textile production and the development of new applications, the traditional approach based on empiricism and experience is not sufficient, but a systematic and interdisciplinary approach is necessary that enable textile machinery smes to:  
  
-make their machine more flexible, productive and efficient to move from mass production and cope with highly variable and functionalised textile products,   
-reduce the huge quantities of energy and other resources required,   
-improve the working conditions by reducing the noise and vibrations which represent threats for the workers and give an old-fashioned vision of the sector to the new generations.   
  
to address this challenge in 2006 the manutex initiative has been jointly launched by the european technology platform for assuring the future of manufacturing in europe (manufuture) and the european technology platform for the future of textiles (textile etp) in order to realise closer collaboration in pre-competitive research and development at european level between the textile and related machinery industries. in this framework, the partners euratex and ita with the support of cematex and in particular its national members acimit and vdma, both participating in the project nu-wave, have performed a preliminary analysis of the scientific and technological bottlenecks, in cooperation with 500 companies. this survey highlighted the need to replace complex kinematic devices (e.g. cams, alternating mechanisms) currently required to obtain distributed actuations starting from a central engine, to reduce high inertia of rotating bodies as well as high level of vibrations from high frequency oscillating masses, to decrease high friction of yarns and textile materials against metallic components as well as to introduce process simulation technologies and modularity concepts for cost-effective design and control of machines and drives.   
  
in line with the strategic research agenda of manutex (see http://www.manufuture.org/documents/manutex-def1.pdf online), nu-wave has been conceived to support textile machinery smes in the design of a new generation of flexible and high-performance machines. research objectives are clearly driven from the needs of the market end users: textile producers are looking for increased performances, modularity, resource efficiency and safety to compete in the global market.   
  
the main objectives of the project can be summarized as:  
to scientifically characterize and integrate advanced materials in the machine building, in particular:  
-composite materials;  
-smart materials;  
-ceramic materials.   
  
to develop and integrate in textile machines novel mechatronics based design concepts, in particular:  
-modular design to organise a complex system (such as a textile machine) as a set of distinct functional components that can be developed independently and then plugged together as well as moved from one machine to another;  
-high power density actuation devices able to replace the very complex power distribution kinematic devices driven by a powerful driving unit with several miniaturised (e.g. 20x20x100mm) actuators independently powered with an actuation frequency of at least 50 hz;  
-distributed control system in which the controller elements are not central in location but are distributed throughout the system with each component sub-system controlled by one or more controllers with sensors integrated in them;  
  
to set a development methodology integrating different virtual prototyping software (e.g. 3d modeller, fem tool, cfd tool) and web-tools, with guided functionalities able to support the non-expert user;  
  
project results:  
  
the nu-wave project is based on a structured approach to innovation, which is commonly adopted by industry in their development activities.  
  
the methodology is assumed to pass through three phases:  
1.scenario analysis;  
2.demonstrators design: functional analysis, conceptual design;  
3.testing results and dissemination: test campaign and dissemination actions  
  
according to the pert diagram and to the activities really performed, the nu-wave project itself can be conceptually divided into these three phases.   
  
for a strong approach to industrial innovation, first of all a company shall set up a strategy and define the technology areas which are necessary to focus on. once the overall scenario and the opportunities are completely known, the company can shift to the second phase of product development, which includes the prototyping activities, the validation phase, the final integration and test campaign. the last phase is not less important and includes all the activities aiming at exploiting the potential of the innovation: the ipr management, the evaluation tools (e.g. qualification under specific tests, norms, directives) and the dissemination activities.  
  
it is important to underline that the innovation process shall not end as soon as the first prototype is produced, but it goes on with a sequence of further actions, aiming at consolidating the innovation, exploiting its potential and making the perception of the enhancements and innovation level easier to communicate.  
  
the scenario analysis  
  
within the first phase, collection and organization of relevant technical and non-technical data have been performed, in order to get the whole picture of current scenario and allow the users (sme and sme-ags) at getting easily results for future development.  
  
the consortium developed new knowledge and performed a scenario analysis at different level, in order to acquire as many data as possible from which the research could start and on which the evolution could be based.   
  
in particular, the activities performed can be summarized as:  
-patent analysis and hot patents collection;  
-collection of the newest patents from far-east;  
-analysis of the scientific literature;  
-collection of datasheet of the newest textile machinery;  
-definition of the technical clusters of innovation.  
  
the interpretation of data, the analysis of the scenario, of who is doing what, allowed the consortium in defining the main technological areas on which the worldwide research is currently pushing.  
  
thanks to that, the consortium has been able to focus the efforts in developing knowledge in the most actual arguments found, avoiding redundancy and increasing the research efficiency that showed high potential for textile industry:  
-friction reduction and wear resistance;   
-reduction of noise and vibrations;  
-mechatronics;  
-modularity of design;  
-computer aided engineering (cae);  
-energy saving.  
  
the huge quantity of interesting data and graphs suggested to structure all single analysis in a simple way, in order to make easier to the reader (potentially all europeans associated smes) to consult the results and find new ideas or interesting topics:  
  
introduction. in order to introduce the reader to the topic, each chapter contains a brief description of the argument, including the important related critical aspects and the existing technological limits;  
  
general analysis. patents and scientific papers have been investigated for figuring out who in the world is leading the industrial and scientific research.   
  
detailed analysis. for each of the main field of investigation has been identified a certain number of recent and interesting areas, representing a sort of roadmap of future development: for this reason, the general analysis has been refined, with a focus on each of the most promising areas of improvement;  
  
textile industry. the last analysis wants to show who, coming from textile industry, is active on a certain topic and the opportunity related to a technology transfer.  
  
demonstrators design  
the second phase started with a technology scouting activity, targeted at defining a portfolio of different possible innovative solutions, for each demonstrator and for each technological area identified in the previous phase.  
  
this activity allowed the rtd performers and smes in identifying the most interesting concepts and the technology on which to invest and build a structured process of product development, avoiding cross roads already beaten by others and proved fruitless. for each demonstrator has been traced a development roadmap, containing all possible alternatives for overcoming actual limitations and a workplan, for its production.  
  
nu-wave demonstrators  
three demonstrators have been developed within the project, as evidence of the new concepts, technologies and knowledge collected by the consortium:  
1.innovative parts for crochet machines: a crochet loom has been improved by modifying the actuation systems of the weft bars and the weft bars themselves. new concepts of mechatronics, innovative control algorithms, innovative coatings and light-weight materials have been the core of the demonstrator;  
2.wear resistance testing stand: the demonstrator is an important tool for nu-wave, since it has the aim of better evaluating wear resistance of machine parts subjected to yarn sliding. the demonstrator is completely shaped on yarn sliding and it can be used as first trial on some parts of demonstrator nâ°1 (particular reference to the thread guide wear resistance increasing objective);  
3.yarn dyeing machine: development of new control sensors and algorithms for implementing the modularity of the plant and allowing fast adaptation and optimization of the dyeing process variables (temperature, salt concentration, and ph). this will increase the plant performances when managing rapid changes in the desired output and addressing high-quality customized production  
  
these industrial results reached within nu-wave were highly appreciated by technicians, researchers and journalists of the sector, as shown by the several expression of interest collected in itma fair - barcelona 2011, by the nu-wave booth (h5-d116).  
  
crochet machine demonstrator  
the rtd performers, together with comez, realized one of the small-scale demonstrators displayed at itma 2011 in nu-wave booth. a twin demonstrator was displayed in comez own booth (in hall 3) for showing the important improvements directly to their own customers.  
  
the comez demonstrator components, though tested and validated with a strict test campaign, still need improvements to fill the gap with market and be presented as potential commercial products integrated within a crochet loom.   
  
in the actual types of knitting machines actuation systems, the cranck-shft mechanism is used, whose aim is to transform the rotary motion of the motor shaft into a rectilinear motion for the positioning of the weft bars.  
  
the mechanism for controlling the bars is based on a crank directly connected to the motor shaft and a slider which pushes the weft bar onto a fulcrum.  
  
the linear displacement of the weft bar depends on the angle between the cranck and the reference plain. each motor step brings about a variable displacement according the sine of this angle.   
  
the precision of the displacement must be within a range of +/- 0.01 mm.   
  
with this kind of transmission, if a wide linear displacement (50 mm) is required while keeping the necessary precision, the displacement angular resolution must be very high (at least 16384 positions per revolution).   
  
in addition, the algorithm for the positioning of the actuator requires a high calculation power since it has to be moved a load whose inertia related to the actuator shaft varies significantly (the same is a function of the sine of the angle).   
  
at present, cranks of 3 lengths (14.5 mm - 20 mm - 30 mm) is used according to the amplitude of the linear displacement to be accomplished.  
  
the displacements vary according to the machine gauge (needle per inch of needles per cm). the minimum gauge corresponds to a linear step of 1.25 mm.  
  
the weights of the bars are as follows:  
-patter bar weight = 1240 g displacement = 30.6 mm;  
-ground bar weight = 3270 g displacement = 10.2 mm.  
  
the positioning must take place in 20 ms (1500 rpm).  
  
the friction (first disjunction), according to measures taken on machines in operation, is comprised between 550 and 2000 g. the friction varies according the temperature since the lubricant cohesion increases at low temperatures.  
  
all the movements of the textile mechanisms on comez machines are currently based on the application of a brushless actuator connected to different types of mechanisms. the actuator is composed of a brushless motor to which - as continuation on the rear side - a converter based on digital technology (dsp) is attached.   
  
  
knitting mechanism - current limitations  
the slider/crank system offers the advantage to be simple, economical and reliable, however has significant limitations:  
-part of the force transferred is lost due to the increase of length of the crank;  
-the precision of the linear position is reduced due to the transformation of the rotary movement into a linear movement;  
-f2 is dissipated in heat over the axial sliding element (bearing brass) and only f1 actuates the bar, due to the split of the force f in two forces f1 and f2.  
  
consequently, keeping on using this type of system:  
-the value of the actuators' torque is increased in order to offset the requests for wider linear displacements which presume longer cranks;  
-the positioning angular resolution is increased in order to guarantee the precision of the linear positioning required;  
-a sophisticated algorithm for the positioning is necessary in order to manage the various movements of the bars;  
-a remarkable part of the energy is lost in friction and transformed in heat in the connecting bearing of the weft bar.  
  
weft bar  
currently the bars are produced with uni 7075 aluminum. steel pins are attached to the bars which allow for the displacing along the longitudinal axle. the pins slide inside bearing brasses. the shape of the bars has been specially designed so as the spring shaft thread-guides fit properly.  
  
the main problem connected with the weft bar is primarily referred to the amount of energy required to make it move back and forth during the working cycle: it strongly depends on the weft bar inertia, thus leading the actual research towards the identification of a novel design in terms of shape and material, primarily targeted on the minimization of the mass and of the energy lost by friction during the sliding movement of pins inside the bearing brasses.  
  
the comez demonstrator showed the feasibility of reducing of more than 50% the weight and up to 80% the energy consumption of the articulated crank-slider system necessary for a single weft bar, by modifying the design, the materials and integrating innovative surface treatments within lightweight carbon-fiber weft-bars and shafts, as well as wear resistant titanium coated guiding pins.  
  
the brushless motor is based on new generation digital signal processor, with high resolution positioning and high efficiency. the acoustic emissions are low and its operating modes allowed to replace all the mechanical devices involved in manufacturing processes on crochet machines, needle looms and warp knitting machines.  
  
the connecting rod was made of aluminum, the body has been re-designed using a polymeric material, reinforced with short carbon fibers, decreasing the overall weight of about 40%; the cylindrical couplings are still made of aluminum, glued with the body.  
  
the weft bar was entirely made of aluminum: it has been redesigned and then produced using epoxy with carbon fiber t700s-c-12000-50c, braided on a structure of balsa wood, an innovative process that enabled the high mechanical characteristics needed. the weight reduction is of more than 50%.  
  
the pins of steel have been replaced with titan pins; the surface of pins has been treated with flame spray, an innovative process that enabled the increase of surface hardness up to that of steel.  
  
the performances of the innovations as a whole are surprisingly high. the stand was measured in vuts facilities, with the aim of comparing the dynamic performance of the original and modified design. the new design, including the new driver, the composite weft bar, a composite connecting rod and an improved slideway, served to reduce the inertial mass and to save the power consumption of the weft bar drive.  
  
the innovative features implemented by nu-wave will strongly affect the cost and then the appealing to customers of the new generation of knitting machine.  
  
energy saving. according to the preliminary tests performed during nu-wave project, the energy consumption of each actuation system could decrease up to 80%, thanks to the reduced friction, the decreased mass and the new electronic control. being more than conservative, we could assume for an industrialized running machine a power consumption of 50% respect to the actual, 93.5 w instead of 187 w, per bar. a 20-bars machine will need around 1.9 kw, instead of 3.7 kw.  
  
if we assume an average value for the cost of kwh of 0.07 to 0.10 euros and that usually the machine is used 24 hours per day, the total savings given by each machine could vary from 95.76 euros/month to 136.80 euros/month, representing an important benefit for industry.  
  
floor-space reduction. according to the preliminary design of the new actuation system developed in nu-wave, the volume of a 20-bars machine has been significantly reduced. this is mainly due to the great reduction of dimensions of the down-sized electrical motors (35-40% less than before, as power installed). the volume occupied by one current 20 bars knitting machine can be occupied by 1.2 new machines: this means that a floor-space currently hosting 10 machines can be revised to contain up to 12 machines, increasing its productivity of the 20%.  
  
mass reduction. the weight of the new actuation system of the knitting machine is 369 g, the 55% less than the previous version (821g). each weft bar will bring a mass saving of 452g, this means a total reduction of more than 9 kg for a 20-bars machine. including the weight reduction of further (conservative esteem) 50 kg related to motors downsizing, the total reduction is of around 60 kg. besides the already treated energy consumption reduction, this allows further cost saving, as shipment concerns. starting from some latest statistics on air shipment price, as an example, the average cost for shipping a machine to china, can be reduced of around 113 euros per machine shipped, that represents more than the 10% of the current mass-related shipment price (around 900 - 1000 euros).   
  
low environmental impact.. in order to assess the lowered environmental impact of the demonstrator, a comparison with the currently commercialized machine has been made, with important results: the carbon footprint calculated for a machine installed in the eu27 area showed a reduction of more than 1kg of co2, per hour of functioning, with respect to the traditional machine.  
  
wear resistance testing stand  
a further result of nu-wave is the small-scale test desk demonstrator developed by naveta and rtd performers, dedicated to wear resistance testing of textile machinery spare parts subjected to yarn friction. different materials and shapes can be easily and rapidly tested, avoiding costs for long test runs and enabling the generation of optimized cost/lifetime plots.  
  
on textile machines, damaging of machine parts from the abrasion of fibrous material occurs, i.e., scraping surface molecules from moving fibers. the greatest ones are radial force, relative velocity and the roughness of moving parts, the highest one is abrasion effect.  
  
by abrasion, machine parts are deteriorated, and this can cause production failures - production decrease or product devaluation.  
  
service life of a part is defining the limiting state of the usage of a part. when assessing life service, mostly a dimension parameter of a part that must be kept is defined.  
  
part wear is examined at all machines where moving parts contact themselves. experience is transferable also into the design of textile machines. from textile semi-products, yarn has the greatest abrasive effect. it moves along the surface of special parts and rubs at high speed and pressure on a part very often.   
  
textile production in the eu started to specialize in technical fabrics. when producing technical fabrics, very strong, coarse yarns are processed, which damage some parts very intensively. yarns are made from polyester, kevlar, glass etc., which are very aggressive materials. abrasive effects of yarns differ remarkably: it depends on fiber length, bend rigidity, fiber roughness, lubrication etc. climatic conditions have an influence during operation, i.e., air temperature and humidity. during textile production, fibrous semi-products are kept under certain pressure. from the point of view of dimensioning mechanisms, ensuring machine input and service life of parts, it is necessary to determine forces.   
  
the problem of wear (abrasion) resistance is worked out by choosing the basic material and part surface. the best parameters are achieved with ceramic parts. if ceramics cannot be used, abrasion resistance is usually settled by modifying the surface of metal parts. the abrasion resistance of steel parts is worked out by hardened steel (both carbon steel and stainless steel), chromizing, surface cementing, dlc surfacing (finishing), nitration etc.  
  
not only weaving machines are concerned. problems occur already in preparatory rooms, in warping on creels (guides, lease and warping reeds, and namely tensioners), in sizing (sizing combs and frames), weft feeders, in finishing, but also in clothing (e.g. scissors for cutting kevlar, trimming off false selvedges etc.).   
  
an inspiration when choosing suitable materials for the production of stressed consumed parts may be found in car industry as well. there, they aim at high life service at minimum costs. today usually special coatings on valves, sparkling plugs, bearing pistons etc. are used.  
  
the yarn subsequently cuts a nut in the point of the largest stress which begins to damage the yarn surface. yarn strength will decrease up to the stage when yarns tear during their processing. it is also disadvantageous from the economic point of view. even a small erosion of yarn surface will evoke reclassifying the goods to lower quality level because when dyeing a cloth, colour difference on the abraded yarn will occur.  
  
damaging parts by yarn abrasion also impacts on the economics of the operation. besides the price of a new part, it is also the loss of operation time for the exchange of parts. at weaving machines, with some parts, there is a problem that the exchange time of a worn out part is optimal in the time where a new warp is being drawn-in. it concerns reed, heddles and drop wires e.g. it is advantageous if the life service of those parts is given in multiples of the processing time of a warp.  
  
at reeds, mainly edging portions are damaged due to higher yarn tension by warp shortening. therefore, either exchanges for new reeds are carried out or naveta offers special surface hardening of edging reed dents, which is financially costly. another solution consists in delivering reeds with exchangeable edging sections. during this solution, considerably less warp threads are drawn-in. the reed centre is used multiple times. up to now, however, it is difficult to set the safe number of surface modified edging reed dents or the length of the exchange section more precise.  
  
at heddles, exchange is carried out on the weaving machine as a whole because it is not possible to differ the starting and the advanced erosions of their surface precisely. after an exchange it is necessary to draw-in the warp as a whole again.  
  
the principle of accelerated course of wear is used to suggest a test methodology and equipment, which would enable to compare the wear / abrasion resistance of the chosen consumed parts of textile machines by provably comparable kind of yarn loading under reversible movement, by max. accelerated course.  
  
the desk simulates the wear on consumables of knitting machines, during millions working cycle, in few hours. a yarn is moved by a pulley and tensioned, with a defined value, by an actuator. the consumable metal part is mounted on an oscillating support, which speed can be varied, to better simulate the real working environment.  
  
the test can last few minutes up to 12 hours; in this period the instrument records all relevant parameters of the test, in order to find relation between the working load/cycle with the results of microscope analysis on the consumable tested.  
  
the major figures of the demonstrator:  
-it shortens needed time and facilitates evaluation in comparison to operational tests;  
-it helps in finding an optimum execution version of a textile machine wearing part;  
-help in looking for compromises of price and quality;  
-help in developing new materials and surface treatments of wear parts in textile machines;  
-a possibility of comparative measurements;  
-also a possibility of optimizing yarn finish in relation to acting of wearing parts.  
  
modular dyeing demonstrator  
in the last years the state of the art of dyeing control system has not changed so much. this demonstrates that innovation in this sector is strongly needed.   
  
a process for the dyeing of a fibrous article makes use of one or more dyes and other chemicals that are adjusted in real time as a function of selected monitored parameters of the dyeing bath. the process includes immersing the fibrous article in a heated aqueous bath with a predetermined ph according to the nature of both the fiber and the dye. salt is also added to the dyeing bath to promote the aggregation of dye molecules which thus become less soluble in the bath while their affinity for the fiber is increased.  
  
most dye houses use standard dyeing procedures for a particular dyeing system. since there can be variations from one lot of fabric to another and there can be some errors in the dyeing variables, the standard dyeing procedures may lead to mismatched and unlevelled dye lots.  
  
these dyed goods may then have to be re-dyed to get the desired result, and this leads to loss in time and resources. it is therefore the desire of dye houses to get the desired shade with good levelness of the fabric in the first process. many researchers have been focusing their efforts to overcome these problems.  
  
the innovative yarn dyeing machine technology is going to be based on the use of the variable optical path spectrometer (vops) as monitoring system for the bath exhaustion, temperature and density of the dyeing bath. those parameters are not the only ones that have to be monitored for obtaining the best dyeing results: salt concentration and ph are also crucial. as matter of fact, the bath exhaustion depends on these parameters as well.  
  
the monitoring system has thus been conceived with the following equipment connected to a pc with a user-friendly interface:  
-vops spectrometer, which allows the measurement of the % exhaustion and dye concentration (the light is both transmitted from the source and acquired after passing through the bath through a optic fiber);  
-temperature probe;  
-conductivity probe, which allows the calculation of the salt concentration;  
-ph probe.  
  
the developed system has the ability to collect real-time spectral measure of the bath with a high degree of accuracy in order to provide dye colour information along with conductivity, ph and turbidity parameters.  
  
the system showed sometimes some minor problems during its functioning. this was justified as the system is still a prototype and needs a further work for final industrialization.  
  
in any case the intense testing campaign showed that the innovative technology introduced with this system is really of help for the dyeing companies. it showed to be strong enough for working in a very harsh environment such a dyeing industry. the end-user companies involved in this evaluation phase gave all their support and demonstrated to be confident in the obtained results.  
  
after the necessary industrialization phase, dye-bath machine will be ready for being installed and integrated in each industrial plant, being able to allow the on-line monitoring of the dyeing bath. besides this, dye-bath machine will be able to help the dyeing operator to perform a corrective action to the bath if needed.  
  
all this innovative functionalities were demonstrated thanks to the performed tests during the last months of the project. all partners were involved in these trials, in order to let the whole consortium finally understand the real potential of the developed prototype.  
  
the 'green label' tool  
one of the nu-wave objectives is to develop a new generation of textile machines characterized by a reduced environmental impact, a smart exploitation of resources and energy and an improved life cycle sustainability.  
  
in collaboration with rtd performers, acimit has created a working group whose purpose was to identify the objective parameters to evaluate the characteristics of eco-sustainability of textile processes. the final output is a 'green label' applicable on the textile machineries of the companies participating to the iniziative, as a reference for carbon footprint.   
  
four main steps necessary to realize the âgreen labelâ have been concluded by the working group:  
1.technical-commercial survey, data collection/evaluation;  
2.identification of a set of indicators to be inserted in the label;  
3.identification of two front-runners (acimit members) in order to perform pilot projects;  
4.creation of a tool ...

# DECOCOAT

Project Acronym: DECOCOAT

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('textile', 42)
* ('decocoat', 28)
* ('products', 22)
* ('yarns', 21)
* ('companies', 20)
* ('project', 19)
* ('dispersions', 17)
* ('industry', 15)
* ('fabrics', 15)
* ('innovation', 14)
* ('textiles', 12)
* ('formulations', 12)
* ('applications', 10)
* ('processing', 10)
* ('articles', 9)
* ('application', 9)
* ('polyolefine', 9)
* ('work', 9)
* ('clothing', 8)
* ('development', 8)
* ('polymers', 8)
* ('yarn', 8)
* ('phthalates', 7)
* ('offer', 7)

executive summary:   
  
the european textile industry is confronted with a constant increase of ecological awareness. for instance, soft pvc is coming under ecological pressure. the polymer not only has high halogen content, but also requires the use of plasticisers.  
  
some of these (e. g. specific phthalates) are toxic and can alter the expression of gender characteristics and are leading to a lowered fertility. some of these chemicals are already banned from selected textile applications (e. g. baby's clothing) via legislation or eco-labels such as ?kotex.  
  
consumer organisation and ecologists are raising the pressure further to limit the use of these products. as a result voices are raised to ban soft pvc containing textile articles further. this is not only to be considered as a thread but also as an opportunity for the textile industry and the smes involved. indeed, if appropriate eco-friendly alternatives are developed, offering in addition technological advantages, a new route for innovative and high-end textile articles becomes available.  
  
the present project, decocoat, is focussing on the development of po based functional polymers for the textiles industry. recent developments within the po production generate new sets of polymers, belonging to the most environmental friendly of all synthetic polymers. thanks to the integrated functionalities and the (block) copolymer composition, a large range of mechanical properties and softness can be reached without the use of plasticisers. within the project, implementation of these novel polymers on textiles were explored using application routes offering the highest flexibility and requiring minimum new investments. the novel developed textiles will offer an ecologic alternative for the soft pvc coated or printed articles.  
  
 project background and objectives:  
  
the need: environmental friendly coating to replace pvc  
   
 the european textile industry is confronted with a constant increase of ecological awareness, reflected into legislation and end consumer concern. for instance, soft pvc is coming more and more under ecological pressure. the polymer not only has high halogen content, but also requires the use of high amount of plasticisers. some of these (for instance specific phthalates) are potentially toxic and can alter the expression of gender characteristics and are leading to a lowered fertility. phthalates in pvc for consumer products and building materials raises concern in relation to particularly sensitive and exposed population groups. in the eu, five phthalates are currently being risk assessed; in denmark, an action plan has been introduced to halve the use of phthalates over the next ten years. other countries, including sweden and germany, have set similar goals. consequently, there is a drive for finding alternatives to the present plasticisers which is likely to grow in the near future. the danish epa had pre-selected five substances for assessment, and in consultation with the industry, six other substances were identified as representatives of the remaining groups of alternative plasticisers. some of these chemicals are already banned from selected textile applications (e. g. clothing for baby's or children coming in contact with the skin) either via legislation or eco-labels such as ?kotex. consumer organisation and ecologists are raising the pressure further to limit the use of these products.  
  
as a result voices are raised â especially in scandinavia-to ban soft pvc containing textile articles further. this should not only be considered as a threat but as an important opportunity for the textile industry and the smes involved to develop new products, getting ahead of eastern european competition and increasing markets. indeed, the development of eco-friendly alternatives with technological advantages opens up a new route for innovative and high-end textile articles, strengthening the position of smes involved in textiles.  
  
the concept: start from europe's strength in polymers  
   
 the project starts from the strengths and opportunities available within the european industry. indeed europe has the lead in the development of chemicals and polymers. this is certainly true for the european po industry, that along with an enormous production capacity is still focussing in r&d of innovative and specialty products. based on the development of new catalyst and processing procedures, a constant stream of new and specially designed po copolymers are generated and made available for the industry. these copolymers cover a large variation in properties such as crystallinity/amorphous balance, melt temperature, low glass transition temperature, softness and variable chemical functionalities generating an adaptable hydrophilic/hydrophobic balance. these novel copolymers are in general created for the melt-processing industry and are more and more applied in a large range of end-products (automotive parts, household articles, toys, etc). due to their specific composition and properties they are used to upgrade and replace other polymer systems including polymers that are less environmental friendly such as pvc (halogen and phthalates content). recently it was also shown that these polymers can be used for extrusion processes and they can also be transferred into stable water dispersions with high solid (â± 50 %) content.  
  
main objectives: explore a novel value chain based on polyolefine coated textile articles.  
  
within decocoat, innovative polyolefine (po) dispersion will be explored for use on textiles. tailored formulations will be evaluated towards implementation into the textile coating industry. therefore, the goal is to develop novel coating processes based on the po formulations for use on yarn and fabric. also the implications on the further processing (e. g. knitting and weaving) of these novel coated textile materials will be investigated with the final goal to realise demonstrators in different areas.  
  
this translates into the following objectives:   
â adaptation and optimisation of the po formulations according the requirements of the applied textile processes  
â development of po coated yarns  
â development of po coated fabrics  
â definition of additives to adapt the formulations according to the processing need  
â functionalisation of the developed coatings using specific additives  
â adaptation of the further processing of yarns and fabrics in order to maximise the added value of the po coated articles  
   
 context of the project in a larger perspective: innovation for the sme-based textile sector.  
  
the european textiles and clothing industry has a longstanding tradition of leadership in terms of innovation, fashion and creativity, and despite increasingly fierce global competition and significant relocation of manufacturing to low-wage countries; it continues to represent one of europe's major industrial sectors with an annual turnover of ca. 200 billion euro and a total workforce of 2 million peopel. it is a major player in world trade, the first in textile exports and the third in clothing. with a total of roughly 200, 000 companies in the enlarged eu, of which ca. 95 % are smes (!), it covers a fascinating industrial landscape, producing a myriad of different consumer and industrial products, using countless knowledge-intensive and highly specialised production processes and related technologies.  
  
a constant stream of innovation is one of the key elements to stay ahead in the ever increasing competition and to create a competitive advantage, preferentially in the area of technical textiles and textile applications with a high added value. this is in accordance with the conclusions from the "european textile platform" who prepared a roadmap for the future of the textile industry and who also defined major area's of innovation the industry should preferentially focus on. therefore, they suggest that research efforts should be directed to:   
â innovation in products with a high technical level  
â innovation in processing allowing the highest production flexibility   
â innovations in specially designed properties and functionalities  
â innovation in high tech markets and high added values  
â innovation in tailor made specialty products for niche markets   
â innovation in products and technologies in respect with ecological requirements  
   
 decocoat is really aiming at the heart of these concerns and could offer a major contribution to most of these requested innovations, in the area of coated or finished textiles. not only the more traditional "fabric coating" but also innovative products via yarn coating technologies are envisaged.   
  
project results:  
  
in order to discuss the key results from decocoat, we follow the main steps needed to realise polyolefine (po) based coated textile articles. this includes the following aspects:   
â identification and characterisation of existing po dispersions  
â tuning and functionalisation of po dispersions  
â po coating on yarns  
â po coating on fabrics  
â processing of po coated yarns and fabrics  
â realisation of demonstrators  
   
 identification of existing po dispersions  
   
 this task encompasses the identification of companies supplying polyolefin dispersions (pods) on an industrial scale. several products were found. to select the most interesting products, the selection criteria applied were: (i) water-based products; (ii) olefin based composition; and (iii) chlorine free products.  
  
based on the information gathered on the pods, it was decided to focus the attention of wp1 on a small set of products. two main producers were contacted and asked for product samples.  
  
a first step was to work on the characterisation of the pods. the goal was to get a feeling for the various pods commercially available, to get to know their basic properties and to gain knowledge on how to tune them into suitable products for textile application. further, also the film forming capacities of the various products were investigated.  
  
tuning and functionalisation of po dispersions  
   
 once the products were characterised, the focus shifted towards tuning and functionalising the po dispersions. two main aspects were investigated: possibilities for integrating colorants in the coated film and for integrating additives that could functionalise the coating formulations. for the latter, several options were investigated: fire retardancy, uv resistance, electrical conductivity, water and oil repellency, â as a result, we learned that the po dispersions can be coloured and that several of the anticipated functionalisations are possible.  
  
po coating on yarns  
   
 an important part of the work related to the coating of yarns with po dispersions. this turned out to be more complex as anticipated. but, by carefully adapting the po formulations and by choosing the right application technology, it became possible to coat both mono-and multifilament yarns with polyolefines.  
  
after the laboratory scale testing, also larger scale, industrial runs were performed, leading to the production of several kilometres of po coated multifilament yarn.  
  
the findings of this work resulted also in a set of rules of thumb for coating yarns with po dispersions.  
  
po coating on fabrics  
   
 also the coating of fabrics with po dispersions was an important part of the decocoat work plan.  
  
it was found that by tuning the pod formulation and be using different coating techniques, textile fabrics (both woven and knitted) could be coated starting with po dispersions. the start of the formulation was the commercially available of-the-shelf pod. these dispersions are on themselves not suited for coating. but, by tuning them with the right additives and the right processing, they could be turned into coating formulations suitable for a wide range of coating techniques (knife coating, padding, screen printing, transfer coating, â). that way, the feasibility of coating textiles with po could be shown.  
  
this resulted in a set of rules of thumb for coating textile fabrics with po dispersions.  
  
processing of po coated yarns and fabrics  
 yarns produced with a surface coated layer of po (polyolefine) have different properties then similar yarns with a pvc coating. therefore, it was important to evaluate if these yarns still can be used in various fabric production processes such as knitting and weaving (as warp and/or weft yarns). additionally, thermo bonding of coated yarns may be of interest in sunscreens and was also looked into.  
  
alternative to processing coated yarns, a plain fabric padded with po could also be envisioned. in such case, the fragile weft structure may be stabilised with po while tuning the transparency by filling more or less meshes with po.  
  
as far as confection (i. e. the transformation of coated fabrics into garments or other textile products) is concerned, only realistic methods currently used at industrial scale at the partners were evaluated. as a result, it could be concluded that thermo bonding, cutting (scissors), sewing and thermo welding is feasible with the coated yarns or fabrics.  
  
realisation of demonstrators  
 within decocoat, the various results were made more concrete via the realisation of 4 demonstrators. all four cases are briefly discussed below.  
  
dem1: sewing yarn with melt bonding potential po coated yarns used as sewing threads offer the possibility that, by additional heat treatment of the seam, a double bonding effect can be obtained: via the non-melting base yarn and via the glue effect of the molten po fraction. in addition it is expected that the stitches will be closed via heat treatment due to the molten po fraction so that the product would regain its impermeability.  
  
this goal was unfortunately not reached. the po coating did not flow sufficiently when heated to seal the holes made during stitching. there is nevertheless still potential in this application, namely for technical yarns used for bonding applications.  
  
dem2: po coated sun screens  
 the goal was to investigate the possibility of po coated open sun screens, to be produced as an alternative to the existing pvc coated sun screens.  
  
the proof of concept could be shown: a po coated polyester yarn could be processed into a woven screen. the po coating of the pes yarns is seen as an environmental friendly alternative for the current pvc extrusion coating of these yarns. however, for the time being this is only possible for high end applications due to the cost of the pods.  
  
dem3: po print on children's clothing. the realisation of a multi-coloured print on children's clothing is the topic of dem3. although not a technical textile, this is still an important model taking into consideration that there have been toxicological problems related to some pvc prints.  
  
by fine tuning the pod formulation and by using various auxiliary products, patterns could be printed on (both woven and knitted) textile fabrics via the screen printing technique. so, the feasibility of printing on textiles with po based formulations for the application of children clothing could be shown.  
  
dem4: po coated work wear/rainwear  
   
 the main demonstrator was to check the feasibility of using po coated fabrics for work wear and or rain wear by making an actual garment.  
  
although functionalisation of the po coatings was possible, e. g. for water and oil repellency, and although an excellent water column could be obtained, not all requirements were met: fire retardant coatings were not feasible, neither were breathable ones.  
  
nevertheless, it could be shown that po coated fabrics are compatible with standard processing techniques, resulting in the making of a ladies rain jacket.  
  
potential impact:  
  
impact:  
  
although the developed polyolefine coatings can be applied to traditional textiles including apparel (especially as they offer an alternative for pvc printed clothing for babies and children), the major application areas envisaged are technical textile applications. this relatively small project can only influence only a limited fraction of the huge technical textile market (currently ca. 25 % of the total textile market corresponding with ca. 13billion euro).  
  
but, on the other hand, the future of the sector and especially of the sme companies involved depends on a multitude and constant stream of "smaller" innovation projects. indeed, projects like this can result in tailor made products with a high added value that will offer a solid basis for an improved competitiveness of the european (textile) sme community.  
  
a further impact is expected concerning the current ecological and human safety concern related to the use of (softened) pvc materials. the presence of potentially toxic products in soft pvc (especially phthalates) along with the fact that pvc is a halogen based polymer, is a major concern within the community and more and more end-users are asking for valuable alternatives. if the po grades are well formulated and functionalised with selected additives that cause no negative effects, the product can offer a real breakthrough. since po grades can be selected that are very soft by themselves the use of plasticisers in these applications can be avoided. these ecological elements (along with recyclability) will offer a major advantage in marketing and makes it possible that a relatively small increase in end price is acceptable.  
  
networking of sme companies.  
  
it is generally accepted that sme companies can benefit largely from networking. on the one hand, a single sme has typically limited resources and its expertise is rather specific and focussed on a particular domain. on the other hand, innovation stems more and more from cross-sectoral collaboration, multidisciplinary research, â large companies can afford to have several groups, and even departments, in-house but this is out of reach for a typical sme company.  
  
therefore, sme companies can benefit of close collaboration with a (large) number of other (sme) companies. this collaboration can be loose but a more structured and integrated way of working in a collaborative network is more appropriate. decocoat allowed the six sme companies participating in decocoat to work together in that way.  
  
indeed, each of the sme companies had its own specific expertise. because of the getting to know during decocoat, the sme partners discovered that they can also benefit from collaboration among each other outside the strict decocoat scope. this is for example the case for the companies schmits and luxilon who are now permanently working together. similarly, also schmits and calcutta work on a common development.  
  
networking of sme companies and rtd centres.  
  
next to the collaboration among the sme partners, also the interaction and collaboration among the rtd centres and the companies is vital. also here decocoat resulted in spin-off ideas for further research and innovation. as an example, aitex and centexbel have been involved in a couple of european research proposals together with a decocoat sme company.  
  
dissemination activities:  
  
the decocoat project was represented by centexbel at the 4th dornbirn conference held on september 17th 2010. here, the project was presented through a powerpoint presentation.  
  
aitex represented decocoat at the 4th international textile congress "competitive innovation, research and technology-based solutions" held last 26th to 28th october in alcoy. a poster was presented and leaflets prepared by centexbel were available in 100 copies.  
  
on january 2011, the spanish ateval magazine featured an article about decocoat.  
  
decocoat was represented at the techtextil conference on may 24-26th in frankfurt. fov, schmits, luxilon, aitex and centexbel was present at this event and a poster was produced to promote decocoat.  
  
all the partners present have disseminated the project in its booth through the project leaflet.  
  
an overview of decocoat public results was presented in a special coating edition of "ctb info" (news letter from centexbel). the article was offered both in dutch and in french. this news letter is spread to over 500 companies. they are mainly belgian textile companies but a relevant part of the companies are either non-belgium but european textile companies or european companies from sectors related to the textile, e. g. chemistry suppliers.  
  
during the event "drivers for the lombardy region textile industry" organised by euratex, the european textile association, and by lombartech the decocoat project was presented as an example of european collaboration by ctb. it was explained that fp7 projects like decocoat enable also relatively small smes from a more traditional sector like textile to collaborate within europe and to work on innovation.  
  
the program of miics2012 (6th mikkeli international industrial coating seminar in finland) is focused on the use of coating technology and its development for near-and medium-term industrial applications. it included a session on coatings for flexible/textile materials. within this session, ctb presented current and future trends of coating on textiles, including a section on the use of polyolefine dispersions based on decocoat outcome.  
  
oral presentation, "high-tech monofilaments for medical and technical applications", place: alcoy (es), october 26-27, description: 4th international textile congress, ca. 100 participants, partner: luxilon.  
  
decocoat was disseminated at the annual conference of the european textile platform in aitex booth through the project leaflet.  
  
a project web-page (http://www.decocoat. org) has been established as a tool to share information of the project and its progress with the public.  
  
exploitation of the results:  
  
key exploitable results.  
  
decocoat enabled the participating sme companies to extend and deepen their knowledge concerning the use of polyolefine (po) dispersions for textile applications. expertise has been gathered on four main domains:   
â adapted po formulations and specific functional additive formulations for po dispersion  
â know-how on the application of po formulations to yarns and on yarn coating  
â know-how on the application (coating and printing) of polyolefine formulations to fabrics  
â know-how on confection possibilities of the po based textile materials  
   
 for each of these domains, the consortium partners were able to extend their knowledge base dramatically. this puts the partners in the position where they can discuss with their clients the use of po based materials.  
  
exploitation beyond decocoat  
   
 the disseminations activities performed in the past, the availability of the project web site and the fact that decocoat has been integrated in some databases created and still creates quite some visibility for the project.  
  
as a result, the project consortium already got a request from a large textile company, not part of the decocoat consortium, who wants to apply the expertise gained on polyolefine dispersions based multifilament yarn coating. this application is currently under negotiation with the relevant decocoat partners.  
  
this shows that decocoat generates opportunities for the sme companies who participated.  
  
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a first step was to work on the characterisation of the pods. the goal was to get a feeling for the various pods commercially available, to get to know their basic properties and to gain knowledge on how to tune them into suitable products for textile application. further, also the film forming capacities of the various products were investigated.  
  
tuning and functionalisation of po dispersions  
   
 once the products were characterised, the focus shifted towards tuning and functionalising the po dispersions. two main aspects were investigated: possibilities for integrating colorants in the coated film and for integrating additives that could functionalise the coating formulations. for the latter, several options were investigated: fire retardancy, uv resistance, electrical conductivity, water and oil repellency, â as a result, we learned that the po dispersions can be coloured and that several of the anticipated functionalisations are possible.  
  
po coating on yarns  
   
 an important part of the work related to the coating of yarns with po dispersions. this turned out to be more complex as anticipated. but, by carefully adapting the po formulations and by choosing the right application technology, it became possible to coat both mono-and multifilament yarns with polyolefines.  
  
after the laboratory scale testing, also larger scale, industrial runs were performed, leading to the production of several kilometres of po coated multifilament yarn.  
  
the findings of this work resulted also in a set of rules of thumb for coating yarns with po dispersions.  
  
po coating on fabrics  
   
 also the coating of fabrics with po dispersions was an important part of the decocoat work plan.  
  
it was found that by tuning the pod formulation and be using different coating techniques, textile fabrics (both woven and knitted) could be coated starting with po dispersions. the start of the formulation was the commercially available of-the-shelf pod. these dispersions are on themselves not suited for coating. but, by tuning them with the right additives and the right processing, they could be turned into coating formulations suitable for a wide range of coating techniques (knife coating, padding, screen printing, transfer coating, â). that way, the feasibility of coating textiles with po could be shown.  
  
this resulted in a set of rules of thumb for coating textile fabrics with po dispersions.  
  
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 yarns produced with a surface coated layer of po (polyolefine) have different properties then similar yarns with a pvc coating. therefore, it was important to evaluate if these yarns still can be used in various fabric production processes such as knitting and weaving (as warp and/or weft yarns). additionally, thermo bonding of coated yarns may be of interest in sunscreens and was also looked into.  
  
alternative to processing coated yarns, a plain fabric padded with po could also be envisioned. in such case, the fragile weft structure may be stabilised with po while tuning the transparency by filling more or less meshes with po.  
  
as far as confection (i. e. the transformation of coated fabrics into garments or other textile products) is concerned, only realistic methods currently used at industrial scale at the partners were evaluated. as a result, it could be concluded that thermo bonding, cutting (scissors), sewing and thermo welding is feasible with the coated yarns or fabrics.  
  
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dem1: sewing yarn with melt bonding potential po coated yarns used as sewing threads offer the possibility that, by additional heat treatment of the seam, a double bonding effect can be obtained: via the non-melting base yarn and via the glue effect of the molten po fraction. in addition it is expected that the stitches will be closed via heat treatment due to the molten po fraction so that the product would regain its impermeability.  
  
this goal was unfortunately not reached. the po coating did not flow sufficiently when heated to seal the holes made during stitching. there is nevertheless still potential in this application, namely for technical yarns used for bonding applications.  
  
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 the goal was to investigate the possibility of po coated open sun screens, to be produced as an alternative to the existing pvc coated sun screens.  
  
the proof of concept could be shown: a po coated polyester yarn could be processed into a woven screen. the po coating of the pes yarns is seen as an environmental friendly alternative for the current pvc extrusion coating of these yarns. however, for the time being this is only possible for high end applications due to the cost of the pods.  
  
dem3: po print on children's clothing. the realisation of a multi-coloured print on children's clothing is the topic of dem3. although not a technical textile, this is still an important model taking into consideration that there have been toxicological problems related to some pvc prints.  
  
by fine tuning the pod formulation and by using various auxiliary products, patterns could be printed on (both woven and knitted) textile fabrics via the screen printing technique. so, the feasibility of printing on textiles with po based formulations for the application of children clothing could be shown.  
  
dem4: po coated work wear/rainwear  
   
 the main demonstrator was to check the feasibility of using po coated fabrics for work wear and or rain wear by making an actual garment.  
  
although functionalisation of the po coatings was possible, e. g. for water and oil repellency, and although an excellent water column could be obtained, not all requirements were met: fire retardant coatings were not feasible, neither were breathable ones.  
  
nevertheless, it could be shown that po coated fabrics are compatible with standard processing techniques, resulting in the making of a ladies rain jacket.  
  
potential impact:  
  
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although the developed polyolefine coatings can be applied to traditional textiles including apparel (especially as they offer an alternative for pvc printed clothing for babies and children), the major application areas envisaged are technical textile applications. this relatively small project can only influence only a limited fraction of the huge technical textile market (currently ca. 25 % of the total textile market corresponding with ca. 13billion euro).  
  
but, on the other hand, the future of the sector and especially of the sme companies involved depends on a multitude and constant stream of "smaller" innovation projects. indeed, projects like this can result in tailor made products with a high added value that will offer a solid basis for an improved competitiveness of the european (textile) sme community.  
  
a further impact is expected concerning the current ecological and human safety concern related to the use of (softened) pvc materials. the presence of potentially toxic products in soft pvc (especially phthalates) along with the fact that pvc is a halogen based polymer, is a major concern within the community and more and more end-users are asking for valuable alternatives. if the po grades are well formulated and functionalised with selected additives that cause no negative effects, the product can offer a real breakthrough. since po grades can be selected that are very soft by themselves the use of plasticisers in these applications can be avoided. these ecological elements (along with recyclability) will offer a major advantage in marketing and makes it possible that a relatively small increase in end price is acceptable.  
  
networking of sme companies.  
  
it is generally accepted that sme companies can benefit largely from networking. on the one hand, a single sme has typically limited resources and its expertise is rather specific and focussed on a particular domain. on the other hand, innovation stems more and more from cross-sectoral collaboration, multidisciplinary research, â large companies can afford to have several groups, and even departments, in-house but this is out of reach for a typical sme company.  
  
therefore, sme companies can benefit of close collaboration with a (large) number of other (sme) companies. this collaboration can be loose but a more structured and integrated way of working in a collaborative network is more appropriate. decocoat allowed the six sme companies participating in decocoat to work together in that way.  
  
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networking of sme companies and rtd centres.  
  
next to the collaboration among the sme partners, also the interaction and collaboration among the rtd centres and the companies is vital. also here decocoat resulted in spin-off ideas for further research and innovation. as an example, aitex and centexbel have been involved in a couple of european research proposals together with a decocoat sme company.  
  
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the decocoat project was represented by centexbel at the 4th dornbirn conference held on september 17th 2010. here, the project was presented through a powerpoint presentation.  
  
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an overview of decocoat public results was presented in a special coating edition of "ctb info" (news letter from centexbel). the article was offered both in dutch and in french. this news letter is spread to over 500 companies. they are mainly belgian textile companies but a relevant part of the companies are either non-belgium but european textile companies or european companies from sectors related to the textile, e. g. chemistry suppliers.  
  
during the event "drivers for the lombardy region textile industry" organised by euratex, the european textile association, and by lombartech the decocoat project was presented as an example of european collaboration by ctb. it was explained that fp7 projects like decocoat enable also relatively small smes from a more traditional sector like textile to collaborate within europe and to work on innovation.  
  
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a project web-page (http://www.decocoat. org) has been established as a tool to share information of the project and its progress with the public.  
  
exploitation of the results:  
  
key exploitable results.  
  
decocoat enabled the participating sme companies to extend and deepen their knowledge concerning the use of polyolefine (po) dispersions for textile applications. expertise has been gathered on four main domains:   
â adapted po formulations and specific functional additive formulations for po dispersion  
â know-how on the application of po formulations to yarns and on yarn coating  
â know-how on the application (coating and printing) of polyolefine formulations to fabrics  
â know-how on confection possibilities of the po based textile materials  
   
 for each of these domains, the consortium partners were able to extend their knowledge base dramatically. this puts the partners in the position where they can discuss with their clients the use of po based materials.  
  
exploitation beyond decocoat  
   
 the disseminations activities performed in the past, the availability of the project web site and the fact that decocoat has been integrated in some databases created and still creates quite some visibility for the project.  
  
as a result, the project consortium already got a request from a large textile company, not part of the decocoat consortium, who wants to apply the expertise gained on polyolefine dispersions based multifilament yarn coating. this application is currently under negotiation with the relevant decocoat partners.  
  
this shows that decocoat generates opportunities for the sme companies who participated.  
  
project website:  
  
http://www.decocoat. org

# DECOCOAT

Project Acronym: DECOCOAT

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('textile', 42)
* ('decocoat', 28)
* ('products', 22)
* ('yarns', 21)
* ('companies', 20)
* ('project', 19)
* ('dispersions', 17)
* ('industry', 15)
* ('fabrics', 15)
* ('innovation', 14)
* ('textiles', 12)
* ('formulations', 12)
* ('applications', 10)
* ('processing', 10)
* ('articles', 9)
* ('application', 9)
* ('polyolefine', 9)
* ('work', 9)
* ('clothing', 8)
* ('development', 8)
* ('polymers', 8)
* ('yarn', 8)
* ('phthalates', 7)
* ('offer', 7)

executive summary:   
  
the european textile industry is confronted with a constant increase of ecological awareness. for instance, soft pvc is coming under ecological pressure. the polymer not only has high halogen content, but also requires the use of plasticisers.  
  
some of these (e. g. specific phthalates) are toxic and can alter the expression of gender characteristics and are leading to a lowered fertility. some of these chemicals are already banned from selected textile applications (e. g. baby's clothing) via legislation or eco-labels such as ?kotex.  
  
consumer organisation and ecologists are raising the pressure further to limit the use of these products. as a result voices are raised to ban soft pvc containing textile articles further. this is not only to be considered as a thread but also as an opportunity for the textile industry and the smes involved. indeed, if appropriate eco-friendly alternatives are developed, offering in addition technological advantages, a new route for innovative and high-end textile articles becomes available.  
  
the present project, decocoat, is focussing on the development of po based functional polymers for the textiles industry. recent developments within the po production generate new sets of polymers, belonging to the most environmental friendly of all synthetic polymers. thanks to the integrated functionalities and the (block) copolymer composition, a large range of mechanical properties and softness can be reached without the use of plasticisers. within the project, implementation of these novel polymers on textiles were explored using application routes offering the highest flexibility and requiring minimum new investments. the novel developed textiles will offer an ecologic alternative for the soft pvc coated or printed articles.  
  
 project background and objectives:  
  
the need: environmental friendly coating to replace pvc  
   
 the european textile industry is confronted with a constant increase of ecological awareness, reflected into legislation and end consumer concern. for instance, soft pvc is coming more and more under ecological pressure. the polymer not only has high halogen content, but also requires the use of high amount of plasticisers. some of these (for instance specific phthalates) are potentially toxic and can alter the expression of gender characteristics and are leading to a lowered fertility. phthalates in pvc for consumer products and building materials raises concern in relation to particularly sensitive and exposed population groups. in the eu, five phthalates are currently being risk assessed; in denmark, an action plan has been introduced to halve the use of phthalates over the next ten years. other countries, including sweden and germany, have set similar goals. consequently, there is a drive for finding alternatives to the present plasticisers which is likely to grow in the near future. the danish epa had pre-selected five substances for assessment, and in consultation with the industry, six other substances were identified as representatives of the remaining groups of alternative plasticisers. some of these chemicals are already banned from selected textile applications (e. g. clothing for baby's or children coming in contact with the skin) either via legislation or eco-labels such as ?kotex. consumer organisation and ecologists are raising the pressure further to limit the use of these products.  
  
as a result voices are raised â especially in scandinavia-to ban soft pvc containing textile articles further. this should not only be considered as a threat but as an important opportunity for the textile industry and the smes involved to develop new products, getting ahead of eastern european competition and increasing markets. indeed, the development of eco-friendly alternatives with technological advantages opens up a new route for innovative and high-end textile articles, strengthening the position of smes involved in textiles.  
  
the concept: start from europe's strength in polymers  
   
 the project starts from the strengths and opportunities available within the european industry. indeed europe has the lead in the development of chemicals and polymers. this is certainly true for the european po industry, that along with an enormous production capacity is still focussing in r&d of innovative and specialty products. based on the development of new catalyst and processing procedures, a constant stream of new and specially designed po copolymers are generated and made available for the industry. these copolymers cover a large variation in properties such as crystallinity/amorphous balance, melt temperature, low glass transition temperature, softness and variable chemical functionalities generating an adaptable hydrophilic/hydrophobic balance. these novel copolymers are in general created for the melt-processing industry and are more and more applied in a large range of end-products (automotive parts, household articles, toys, etc). due to their specific composition and properties they are used to upgrade and replace other polymer systems including polymers that are less environmental friendly such as pvc (halogen and phthalates content). recently it was also shown that these polymers can be used for extrusion processes and they can also be transferred into stable water dispersions with high solid (â± 50 %) content.  
  
main objectives: explore a novel value chain based on polyolefine coated textile articles.  
  
within decocoat, innovative polyolefine (po) dispersion will be explored for use on textiles. tailored formulations will be evaluated towards implementation into the textile coating industry. therefore, the goal is to develop novel coating processes based on the po formulations for use on yarn and fabric. also the implications on the further processing (e. g. knitting and weaving) of these novel coated textile materials will be investigated with the final goal to realise demonstrators in different areas.  
  
this translates into the following objectives:   
â adaptation and optimisation of the po formulations according the requirements of the applied textile processes  
â development of po coated yarns  
â development of po coated fabrics  
â definition of additives to adapt the formulations according to the processing need  
â functionalisation of the developed coatings using specific additives  
â adaptation of the further processing of yarns and fabrics in order to maximise the added value of the po coated articles  
   
 context of the project in a larger perspective: innovation for the sme-based textile sector.  
  
the european textiles and clothing industry has a longstanding tradition of leadership in terms of innovation, fashion and creativity, and despite increasingly fierce global competition and significant relocation of manufacturing to low-wage countries; it continues to represent one of europe's major industrial sectors with an annual turnover of ca. 200 billion euro and a total workforce of 2 million peopel. it is a major player in world trade, the first in textile exports and the third in clothing. with a total of roughly 200, 000 companies in the enlarged eu, of which ca. 95 % are smes (!), it covers a fascinating industrial landscape, producing a myriad of different consumer and industrial products, using countless knowledge-intensive and highly specialised production processes and related technologies.  
  
a constant stream of innovation is one of the key elements to stay ahead in the ever increasing competition and to create a competitive advantage, preferentially in the area of technical textiles and textile applications with a high added value. this is in accordance with the conclusions from the "european textile platform" who prepared a roadmap for the future of the textile industry and who also defined major area's of innovation the industry should preferentially focus on. therefore, they suggest that research efforts should be directed to:   
â innovation in products with a high technical level  
â innovation in processing allowing the highest production flexibility   
â innovations in specially designed properties and functionalities  
â innovation in high tech markets and high added values  
â innovation in tailor made specialty products for niche markets   
â innovation in products and technologies in respect with ecological requirements  
   
 decocoat is really aiming at the heart of these concerns and could offer a major contribution to most of these requested innovations, in the area of coated or finished textiles. not only the more traditional "fabric coating" but also innovative products via yarn coating technologies are envisaged.   
  
project results:  
  
in order to discuss the key results from decocoat, we follow the main steps needed to realise polyolefine (po) based coated textile articles. this includes the following aspects:   
â identification and characterisation of existing po dispersions  
â tuning and functionalisation of po dispersions  
â po coating on yarns  
â po coating on fabrics  
â processing of po coated yarns and fabrics  
â realisation of demonstrators  
   
 identification of existing po dispersions  
   
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 for each of these domains, the consortium partners were able to extend their knowledge base dramatically. this puts the partners in the position where they can discuss with their clients the use of po based materials.  
  
exploitation beyond decocoat  
   
 the disseminations activities performed in the past, the availability of the project web site and the fact that decocoat has been integrated in some databases created and still creates quite some visibility for the project.  
  
as a result, the project consortium already got a request from a large textile company, not part of the decocoat consortium, who wants to apply the expertise gained on polyolefine dispersions based multifilament yarn coating. this application is currently under negotiation with the relevant decocoat partners.  
  
this shows that decocoat generates opportunities for the sme companies who participated.  
  
project website:  
  
http://www.decocoat. org

# ECOPAT

Project Acronym: ECOPAT

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('fibres', 53)
* ('heating', 52)
* ('properties', 38)
* ('material', 37)
* ('injection', 34)
* ('matrix', 28)
* ('materials', 26)
* ('project', 23)
* ('induction', 22)
* ('temperature', 21)
* ('compression', 20)
* ('samples', 20)
* ('plastics', 18)
* ('processing', 17)
* ('results', 15)
* ('production', 14)
* ('strength', 14)
* ('process', 14)
* ('pellets', 14)
* ('manufacturing', 13)
* ('parts', 13)
* ('products', 12)
* ('polymer', 12)
* ('research', 12)

executive summary:  
  
the stationary technical and technological content in materials, machinery and products of the material handling sector together with the high percentage incidence of costs due to manual operations have resulted in a heavy rise of products being imported from low labour cost countries, such as china. launching cost-competitive products with high technological content and superior technical performances could indeed face this trend. this perfectly marries the wish of plastics manufacturers. as a matter of facts, the manufacturing of plastic products has dramatically decreased during the last years. therefore, several smes are opening their market to a wide range of not exploited sectors and developing advanced/innovative products through the use of cutting edge materials and technologies. the hand pallet truck (hpt) production has been identified as one possible application where techno-plastics could play a crucial role in, totally modifying the performances as well as the business of the material handling sector.  
  
project context and objectives:  
  
the stationary technical and technological content in materials, machinery and products of the material handling sector together with the high percentage incidence of costs due to manual operations have resulted in a heavy rise of products being imported from low labour cost countries, such as china. launching cost-competitive products with high technological content and superior technical performances could indeed face this trend. this perfectly marries the wish of plastics manufacturers. as a matter of facts, the manufacturing production of plastic products has dramatically decreased during the last years. the economic crisis has hit the plastics industry severely for the first time in more than 30 years, causing the global plastics production to steadily decrease since 2008. there is therefore a huge need for the plastics industry to overcome the ongoing crisis and to come out with major potentials.  
  
therefore, several smes are paving the way to new business strategies by opening their market to a wide range of not exploited sectors and developing advanced as well as innovative products through the use of cutting edge technologies. in particular omp, involved in the manufacturing of plastic components mainly for the electro-mechanical, conditioning and furnishing industrial sectors, has explored the potential of introducing plastics manufacturing techniques and technologies in the field of material handling, indeed a sector which could deeply benefit from the advantages provided by employing lighter materials. the hand pallet truck (hpt) production has been identified as one possible application where techno-plastics could play a crucial role in, totally modifying the performances as well as the business of the material handling sector.  
  
hpts are handling trolleys able to raise pallets of goods or small containers slightly and to move them safely, thus increasing the efficiency in mechanical handling operations and making easier the unattractive manual labour. despite of their apparent simplicity, hpts are quite articulated objects. two parts, namely the chassis (which consists of the "chest" and the forks welded together into one piece) and the hydraulics, are the key components of standard hpts. in addition, the truck is equipped with front and rear wheels and a vertical tow bar with a loop handle on top. few strokes of the tow bar allow the user to actuate an oil pump located inside the hydraulic unit body which causes the frame to lift up. a rocker arm and push rods positioned below the frame make the two forks to evenly lift with respect to the ground. bearings and breaks let the operator nimbly and safely move weights as high as 2.5 tons for easy material storing/handling/transport. the hpts main parts are typically made from sheet steel that is further bent and cut into the right profiles to make the parts. there are also a small number of special stainless steel trucks produced for particular end uses, e.g., in environments where it may be in contact with corrosive substances or for extra hygienic applications.  
  
several potentials and advantages are linked to the introduction of lighter polymeric materials in the hpt production, as low service weight, that reflects in higher manageability and lower manoeuvre efforts improving the operator working conditions, reduction of raw materials and manufacturing costs, high technical and technological content which prevents the manufacturing steps to be exported to low labour cost countries, major chemical inertia which would reduce corrosion and contamination risks thus allowing hpts healthy use in the food industry within wet/salty environments where stainless steel hpts are nowadays employed, significant operation noise reduction, eco-compatibility, improved functional ergonomics.  
  
self-reinforced plastics are in principle suitable materials for the hpt fabrication. in these materials, a polymeric matrix is reinforced with high-tenacity fibres or tapes of the same polymeric family, such as polypropylene-reinforced polypropylene, creating a material with typically 3-5 times the strength and stiffness of the un-reinforced polymer, giving the ability to use less material for the same mechanical properties in a component. additionally, unlike glass or carbon reinforced plastics, self-reinforced plastics are not contaminated with high levels of mineral fibres, so they have the same level of both recyclability and density as the base polymer.  
  
within this framework, the main aim of the project ecopat is to design and develop the new generation of all-plastic, lightweight, chemically passive and cost-effective hpts to be efficiently used in material handling applications.  
  
the main drivers and needs which address this specific goal are:  
1. to improve hand pallet truck technical characteristics and operational performances, such as strength, stiffness, lightness, life cycle, to name but a few;  
2. to reduce hand pallet truck environmental impact through the employment of resource efficient manufacturing processes;  
3. to improve health and safety working conditions;  
4. to extend business markets and employment sectors by guaranteeing technically competitive cost-effective hpts.  
  
based on these primary drivers, the project has been broken down into a series of likely solutions to the problems. fostering research on self-reinforced plastics and moulding technologies needed to produce components from this new family of materials is key to the development of novel hpts with high technical and technological content. at the time of the proposal submission, early commercial grades of self-reinforced plastics were only available as non-flowing sheet materials, which was restricting their use to simple parts with constant wall thickness. moreover, the properties of plastics were only improved by adding mineral powders or fibres, which increases the weight of the material, significantly reduces the recyclability (and the purity of the recyclate) and increases the wear of tools and processing equipment. in this context, the project ecopat would lead to a step change in cutting-edge self-reinforced plastics technology by developing flowing and mouldable versions of self-reinforced plastics. complex, net-shape parts would be possible, thereby reducing material use and eliminating trimming waste and process energy. this would reduce the amount of material required to make a part and open the door to a vast range of applications for these sustainable materials.  
  
the related scientific and technical objectives which mainly concern self-reinforced plastics definition and manufacturing processes were identified to be:  
- identification of the most suitable polymer materials to be processed both as matrix and fibres among polyolefins, polyamides and polyesters, based on a critical analysis of their mechanical and thermal properties;  
- maximization of the difference between the melt temperature of the matrix phase and the temperature at which the reinforcement phase becomes unstable;  
- identification of suitable impregnation methods of the high melting polymeric fibres with the low melting polymeric matrix to produce self-reinforced composites for subsequent injection and compression moulding;  
- determination of suitable moulding process conditions taking into account the need for selectively pre-heating â by means of classical and novel heating techniques â the compound in order not to affect the properties of fibres;  
- manufacturing of small-scale samples and definition of an experimental testing campaign introductory to analyze the developed self-reinforced plastic characteristics in terms of mechanical and chemical properties;  
- designing of hpt components through the identification of the most simple hpt geometry though taking into account the static and dynamic structural response of the parts, the constraints from the moulding processes and the need for easy assembling/disassembling;  
- full-scale prototype manufacturing followed by its industrial validation accomplished through both traditional testing procedures and material handling in-field demonstrations;  
- dissemination of the findings/results of the project and patent issue request.  
  
the claimed scientific and technical objectives have been achieved thanks to the production of one full-scale hpt prototype made of glass-reinforced plastic which has allowed the final evaluation of the performances of the product and the benefits on health and safety in handling environments. the novel hpt is more than 55% lighter than traditional steel pallet trucks which turns into easiness of use, greater manoeuvrability and reduced noise and is also deemed to have better aesthetical quality, easiness in keeping it clean and strong resistance to corrosion. the novel hpt has therefore considerably improved handling performances over existing products though still allowing the safely lift of loads up to 1000 kg.  
  
in parallel, basic research on self-reinforced plastic materials and their manufacturing processes has been conducted in the project, with the future aim to apply this novel category of plastics to the hpts production. dog-bone samples have been produced from self-reinforced pellets and sheets by injection and compression moulding processes and used for characterization of mechanical and physical properties. also, two heating methods have been applied, i.e., classical resistance heating and novel induction heating. test samples have been compared against percentage and orientation of reinforcing fibres, layout and processing conditions.  
  
the following conclusions have been achieved:  
a) despite the narrow processing window between low melting matrix polymer and high melting reinforcing fibres and independently on the heating system applied, the fibres still exist in the test samples.  
b) injection moulded samples have only marginally improved mechanical properties over the un-reinforced samples because of relaxation, partial degradation and agglomeration of fibres. further research is needed to improve the properties of self-reinforced pellets and their application to the injection moulding process before proceeding with the scale-up of the processing route â co-extrusion and injection moulding â from laboratory to industrial level.  
c) compression moulded samples show considerably increased mechanical properties over the un-reinforced samples. mechanical properties evidently benefit from the presence of fibres especially if oriented along the direction of the applied load. no further basic research is needed but the scale-up of the processing route â winding and compression moulding â from laboratory to industrial level.  
d) induction heating is proved to allow shorter processing cycles and faster controller response, to be more energy-efficient and not to affect the properties of the self-reinforced material. if applied to the moulds for compression, it requires careful design supported by fem analyses to ensure uniform heating of the parts. oppositely, its application to injection equipment is easy and turns into energy savings.  
  
the consortium's common purpose in relation to the project ecopat is to ultimately achieve a commercially competing material/technology/product to be introduced in the respective market. the project is therefore a business-oriented initiative, aimed at both:  
1. proving in a first instance the technical viability of the intended processing routes to better evaluate a possible industrial exploitation for the research advancements and results achieved concerning self-reinforced polymeric materials and related moulding technologies in a medium and long term perspective;  
2. drawing concrete perspectives towards commercialization of the novel hpt already designed, developed and tested in a short term perspective.  
  
accordingly, the 4 smes of the consortium (omp, iti, chabe and constr) joined a clearly business-oriented consortium that also involved the large enterprise lift which will become an important industrial as well as commercial partner for the proposing smes. together these partners represent a complete supply chain as well as a strong business partnership in view of a possible mass production and commercialization of the novel hpt. the project ecopat thus represents a big opportunity for the smes to increase their technical competitiveness and economical advantage in the short term period.  
  
project results:  
  
the concept of the project ecopat is based on the development of self-reinforced plastics (srp) to be employed as materials suitable for the manufacturing of structural parts of hpts. the starting point of the project was a deep investigation of materials from the family of polyolefins, polyamides and polyesters suitable for the considered application. polymer features which are relevant are directly linked to mechanical strength, processing conditions, recyclability and cost. material families were compared with respect to these features and selection of most suitable polymers was done.  
  
in parallel, initial considerations on payload capacity, dimensional constraints, weight, noise and safety characteristics and on specific requirements for the hpt together with a static multi-body analysis performed on a standard steel hpt allowed the definition of minimum specifications in terms of structural, thermal and chemical properties for the material and the parts that make up the truck itself. results obtained guided the selection of the new srp material with related compounding and moulding processes. in this first phase of the project, minor activities were also developed in parallel.  
  
the project website was created and the methodology to drive the project results towards attractive markets with specific business strategies aiming at the generation of profits was defined. experimental research was then conducted to study the behaviour of selected polymers during melting and crystallization. the melting and crystallization temperatures of investigated polymers were determined by means of differential scanning calorimetry (dsc). based on the analysis of dsc heating and cooling curves as well as the derivative (ddsc) of the melting and crystallization curves â the last determining the temperature when the melting and crystallization occur with the highest intensity â several thermal properties were determined. careful design of selected class of polymers targeting well distinguishable processing windows was conducted to reduce the matrix melt temperature and to increase the thermal stability of fibres. as the difference between melting temperature of selected polymers is rather low, the danger exists that both elements of composite melt during heating. to avoid such situation, the effect of nucleating agents onto the thermal properties of the selected polymers was investigated.  
  
also, the heating system shall keep the melt temperature as close as possible to the matrix melt temperature during both compounding of matrix polymer with reinforcement polymer and during compression/injection moulding of the compound. possible heating principles â resistance, infrared, microwave and induction â were therefore deeply investigated. two most promising heating methods were identified. at this point of the project, research on compounding techniques, moulding technologies and heating systems serving the production of self-reinforced plastics in suitable forms to feed the respective moulding processes had to be divided into different routes. briefly, self-reinforced polymeric materials in the form of sheets and pellets were produced to be used in either compression or injection moulding processes. both types of self-reinforced materials were obtained from commercial bi-component fibres as well as from neat polymers.  
  
customized experimental setups were designed and developed and lab-scale experiments were conducted. induction heating as well as resistance heating were also applied to moulding machines and compared against cost-effectiveness, energy-savings, temperature control characteristics and properties of the test samples produced. the main science and technology (s&t) results and exploitable foreground generated within the project are described with detail in the following together with further research steps necessary to achieve a maturity level for the materials, technologies and products developed in the project allowing their industrial and commercial exploitation.   
  
pellets and sheets from commercial bi-component fibres commercial bi-component fibres were initially used to produce self-reinforced semi-finished sheets and pellets and feed injection and compression moulding machines. semi-finished non-woven sheets were produced through thermo-bonding process directly derived from the textile industry.   
  
since the process heats the bi-component fibres up to their softening temperature, no change of properties occurs, i.e. the properties of the non-woven sheets are those of the commercial raw material. pellets were instead produced by means of the extrusion process. because during extrusion the material undergoes phase change and is subjected to high temperatures and pressures, morphological and physical characterization were needed to assess the presence of fibres and the rheological properties of the compound. tests on injection moulding with pellets and on compression moulding with both pellets and non-woven sheets were done with the aim to optimize processing conditions of these materials. results of mechanical and physical tests on compression moulded samples show that: - reinforcement pp fibres caused the growth of the tensile strength of moulded srp compound up to 86% in comparison to low strength pp matrix, reaching the rm value 44.7 mpa; - together with tensile strength growth the elastic modulus decreases; the minimum value of elastic modulus was found for the srp sample with the highest tensile strength. in comparison to matrix material, the srp compound shows decrease of elastic modulus up to 18%; - elongation at break of srp compound is significantly lower in comparison to matrix material value and decreases by about 57 â 64%. results of mechanical and physical tests on injection moulded samples show that: - process conditions did not save the reinforcement fibres which were submitted to considerable degradation; - mechanical properties of samples are comparable to properties of unreinforced material.   
  
the approach with the use of commercial bi-component fibers as a raw material for compression and injection molding technologies showed to be a low cost and effective method to obtain srp compounds. initial use of these commercial fibres allowed the consortium getting insight into behaviour and processing of self-reinforced materials. this foreground generated was indeed useful in the next production of own-made self-reinforced materials and their moulding.   
  
sheets from neat polymers metocene pp matrix polymer and nucleated moplen hp500n reinforcement polymer were used to produce semi-finished sheets. semi-finished sheets were produced by means of a motorized winding process which allows laboratory production of uni-directionally and bi-directionally self-reinforced sheets with different combinations of reinforcing layers. sheets were then pressed and plates heated up by resistance and induction heating alternatively. the applied method of pressing of oriented polypropylene fiber layers and low-melting pp film leads to effective production of spc of acceptable mechanical properties.   
  
when applied as composite matrix, polypropylene metocene 648t facilitates lowering the temperature of spc pressing. however, it requires precise selection of processing conditions which would enable a proper connection of matrix with reinforcing phase, while preserving the excellent mechanical properties of the latter. additional challenge is the choice of film layer of appropriate thickness and the amount of fiber layers which is crucial to obtain a composite containing maximum number of fibers and the most advantageous mechanical properties.   
  
the results of tensile strength tests can be considered satisfactory. significant increase of tensile strength in comparison to neat matrix can be obtained with even small amount of oriented pp fibres into pp matrix. when the content of fibres in the composite amounts to about 30% tensile strength equals 130 mpa (about +225% in comparison to neat matrix) while e modulus is about 1.7 gpa (about +20% in comparison to neat matrix). by the way, the mechanical properties of spc compound substantially depend on reinforcing fibres arrangement. the fibres arranged parallel to the load direction make the material clearly stiffer and reinforced. on the other hand, perpendicular arrangement of the fibres results in material weakening. tensile tests of samples from compression molding with inductive system, despite technical problems like non uniform heating and matrix flow from mould show very common results.   
  
pellets from neat polymers lumicene copp matrix polymer and nucleated moplen hp500n reinforcement polymer were used to produce pellets by means of co-extrusion process. because during co-extrusion the material undergoes phase change and is subjected to high temperatures and pressures, morphological and physical characterization were needed to assess the presence of fibres and the rheological properties of the compound. careful tuning of processing conditions assures presence of fibres in the pellets. pellets were then injection moulded by simple piston machine, whose barrel was heated up by resistance heating and induction heating alternatively. dogbone samples were produced with fibres still existing. tests for characterization of mechanical and physical properties of these composite materials followed. the results of tensile strength tests can be considered satisfactory. when the content of fibres in the composite amounts to about 35% tensile strength equals 30 mpa (about +7% in comparison to neat matrix) while e modulus is about 1.5 gpa (about +10% in comparison to neat matrix). half quantity of reinforcing fibres yields the same results.  
  
the probable reason for this unexpected behaviour is aggregation of fibres inside the samples for high fibre quantities. tensile tests made on samples produced by injection moulding with induction heating system show very similar results.   
  
induction heating applied to laboratory compression moulding machine the tests with induction heating confirm this heating method is more efficient than resistance one, considering particularly cycle time which can be shorter thanks to faster heating of the mould at the same or even at lower value of heating power. simultaneously the temperature control is more accurate and keeping a practically constant temperature while compressing is possible â the temperature deviation does not exceed 0.5â°c. however the main problem of this heating method applied for compression moulding is non-uniform temperature distribution on the moulding surface of the mould.   
  
this strongly depends on the mould and inductor design. in general it seems to be impossible to ensure ideal uniform heating â by very careful analysis in order to ensure the uniform heating of the part to be moulded. in order to ensure the temperature distribution to be possibly most uniform, an inductor geometry optimization is necessary. the optimum inductor design may be done by careful fem analysis of induction heating process.   
  
induction heating applied to laboratory injection moulding machine investigations of induction heating system undertaken for piston injection machine show this heating technique can be easily adjusted and applied to existing injection machine. in opposite to compression moulding where the design of inductor and heating parameter strongly depends on shape of molded part and must be done for each case individually, a design of barrel induction heating system depends only on barrel geometry, numbers and localization of heating zones and plastic processing parameters. the numerical experiments by fem simulation as well as laboratory trials show high heating efficiency and excellent temperature distribution along the heated steel tube.   
  
hpt prototypes the design and prototyping of frame and hydraulic body parts and related moulds were carried out taking the glass-reinforced composite as reference material. static structural analyses and dynamic impact analyses were performed considering both glass-reinforced polyamide and self-reinforced polypropylene properties. the design load was changed from 1 ton for the glass-reinforced material to 200 kg to reflect the reduced mechanical properties of the self-reinforced pp material when produced by injection moulding. moreover, numerical analyses of the injection moulding process were done for both materials. the prototypes of the project, namely: - the frame and the hydraulic body made of glass-reinforced composite, - the assembled version of the hpt with parts made of glass-reinforced composite, - the lever of the hydraulic group made of the novel self-reinforced pp material, were successfully produced and tested on test benches. the full glass-reinforced hpt prototype was also used for in-field demonstration and real life operation loading and moving pallets with an average weight of 700/800 kg each.   
  
further research necessary the results claimed by the project and summarized in:  
1. self-reinforced polymeric materials for injection and compression moulding,  
2. induction heating technology for injection and compression moulding,  
3. full-scale glass-reinforced hand pallet truck prototype, have reached a different level of maturity in terms of potential industrial and commercial exploitation. though the project has successfully demonstrated the basic technical and technological feasibilities concerning production of self-reinforced polymeric materials in different forms and their use in injection and compression moulding processes, further research is indeed necessary to overcome the limitations encountered above all for the injection moulding route. the limits of the achieved results and proposed next steps are detailed in the following.   
  
injection moulding route the main achievement is that the fibres still exist and are visible in the moulded parts despite: â the narrow processing window (about 30â°c) between low melting copp matrix and high melting reinforcing ipp fibres; â the double heating process that matrix and fibres undergo (co-extrusion at first and secondly injection moulding); â the heating system employed during injection (induction or resistance). also, the fibres do not cause weakening of the mechanical properties of the samples, i.e., they do not act as inclusions causing sudden failure of the material. nevertheless, the fibres improve only marginally the mechanical properties of the un-reinforced matrix material (about 7 to 10% increase in e modulus and tensile strength). in addition, despite two types of pellets were produced with different amount of reinforcing fibres (35% and 17%), samples with higher amount have same mechanical properties than those with lower amount.  
  
this unexpected behaviour might be due to several reasons such as:  
- relaxation of fibres. the high mechanical properties of the fibres in their drawn condition are lost during injection moulding, when fibres tend to bend. this behaviour might be limited by reducing the length of the fibres and the diameter of the bundles the fibres are arranged in;  
- degradation of fibres. the temperature of the melt â which includes reinforcing fibres at solid state â increases crossing the injection gate due to shear against the gate walls. the local increase of temperature might yield softening or even melting of fibres despite the high velocity of the flow. the type of injection gate is therefore very important. for instance, slit gates would be preferable to point gates since the orifice is larger. the selection or re-design of best type of injection gate could reduce this behaviour;  
- agglomeration of fibres. the fibres are arranged in tight bundles. the melt matrix material does not flow in the bundle properly surrounding each fibre in the bundle. this causes not homogeneous distribution of fibres and not proper bonding between fibres and matrix material. the injection machines equipped with a screw might help distributing the fibres in a more homogeneous way. also, the co-extrusion process might be revised to avoid agglomeration since the beginning. for example, the number of tight bundles may be increased, each containing reduced number of fibres. this would improve penetration of melt matrix among the fibres and matrix-fibres adhesion. concerning induction heating system applied to existing injection machines, the outcome is summarized in the following: - this heating technique can be easily adjusted and applied to standard equipment without a great manufacturing impact. the main contribution to the overall equipment cost is the power supply unit, whose impact is reduced in % for big machines;  
- induction heating does not affect the properties of the self-reinforced material, which are practically equal to the ones of samples produced by employing standard heating system;  
- induction heating allows fast controller response enabling injection of self-reinforced pellets characterized by a narrow processing temperature window and ensuring small variations of barrel temperature during injection and high heating efficiency which turns into energy savings. on the basis of the deep knowledge acquired during the 2-years project, further research is needed to improve the co-extrusion and injection moulding processes and proceed with their scale-up from laboratory to industrial level. the partners agree that a long term exploitation perspective is required. compression moulding route the main achievements are:  
- the applied method of pressing oriented pp fibre layers and low melting pp film alternately leads to effective production of single polymer composites of acceptable mechanical properties â with about 120 mpa tensile strength and 1.7 gpa e modulus, mechanical properties evidently benefit from presence of fibres if oriented along the direction of the applied load;  
- the mechanical properties significantly change with fibre content and orientation in the material as well as with matrix-fibres bonding properties. concerning induction heating system applied to existing compression moulding machines, the outcome is summarized in the following:  
- induction heating applied to the mould allows the processing cycle to be shorter and more energy-efficient, but it requires very careful fem analysis in order to ensure the uniform heating of the parts. the temperature distribution may be non-uniform even for a simple shape of the mould;  
- induction heating does not affect the properties of the self-reinforced material, which are practically equal to the ones of samples produced by employing standard heating system;  
- induction heating allows fast controller response ensuring high heating efficiency which turns into energy savings. hpt prototype on the basis of the deep knowledge acquired during the 2-years project, no further basic research is needed but the scale-up of the process â winding and compression moulding â from laboratory to industrial level. possibility of exploitation in the medium term is achievable. the full hpt prototype was used for in-field demonstration and real life operation loading and moving pallets with ...

# BIOAGROTEX

Project Acronym: BIOAGROTEX

programme & topic: FP7-NMP NMP-2007-4.0-2

Most frequent returning words in objectives:

* ('properties', 45)
* ('products', 31)
* ('processing', 30)
* ('production', 29)
* ('fibre', 28)
* ('extrusion', 27)
* ('formulations', 25)
* ('process', 24)
* ('conditions', 22)
* ('development', 22)
* ('fibres', 19)
* ('routes', 19)
* ('textile', 19)
* ('agrotextiles', 17)
* ('developed', 16)
* ('biopolymer', 15)
* ('application', 14)
* ('tests', 14)
* ('processability', 14)
* ('project', 14)
* ('water', 14)
* ('durability', 13)
* ('applications', 13)
* ('materials', 13)

executive summary:  
  
increasing oil-prices, a growing threat of oil-shortages, greenhouse gases and their effect on climate change, are elements that contribute to the concern for the future of our oil based economy. the search for biobased polymers and a more extensive use of the natural resources will be needed to cope with these problems and to initiate growth in the biobased economy. agrotextiles can offer a very attractive end market in this regard. at the moment the market is dominated by polyolefin' based agrotextiles. other products are based on natural fibres but are degraded too fast to be very attractive. bioagrotex aims at developing novel fully biobased agrotextiles with a drastically reduced impact on environment.   
  
different production routes are followed to develop this type of end product.  
  
in a first route standard natural fibre based groundcovers are upgraded via application of bioresins including functional additives. for the natural fibres either recycled or upgraded side fractions of linseed or hemp production can be used. properties of these fibre fractions are improved by optimising the fibre preparation process, including enzymatic retting or pretreatment. upgrading the durability is performed via furan based bioresins specially developed for this application in order to control reactivity of the resin and the flexibility of the woven or non-woven fibre mats. an alternative route using partly oil based chemicals is developed as well with included functionality to delay degradation. it is shown in lab trials using soil burial and q-uv tests along with field trials that the developed products have a considerable extended lifetime in normal usage (greater than double).  
  
in a second route melt processable biopolymer formulations either starch based or pla based are evaluated for their potential in textile extrusion processes including: staple fibre, monofilament yarns, multifilament yarns and tapes. processes are optimised to obtain the appropriate properties.   
  
the objective to use starch based thermoplastic in these applications couldn't be reached. improved formulations were developed that allows producing monofilaments, multifilaments and tapes, but mechanical properties are still insufficient for developing industrial products.  
  
with pla based formulations the complete range of textiles can be produced with acceptable properties for further processing, including production of non-wovens, knitted and woven fabrics. also a range of functionalization routes either to improve processability and properties, to control or improve the durability of the products and to introduce specific functionalities like: colour, flame retardancy and anti-microbial properties. also durability of these materials is tested in laboratory conditions and in real life leading to an expected life time of at least three to five years.   
  
project context and objectives:  
  
2 summary description of project context and objectives   
  
2.1 context  
  
increasing oil-prices, a growing threat of oil-shortages, kyoto agreements on greenhouse gases, environmental effects and climate changes, are all elements that contribute to the concern for the future of our oil based economy. europe is gradually preparing the shift towards a biobased economy, a multistep process that will take decennia to come to its completion. initiatives are required to start-up this process of change and to explore at an early stage the possibilities offered by products already under development.   
  
textiles and especially agrotextiles offer a very attractive end market. volumes in this market area are high and fast growing. at present, products are mainly based on polyolefinâs (greater than 200ktonnes/annum in europe) and to a lesser extent other petrochemical polymers such as pa and pet are used. in most cases these agrotextiles are at the end-of-life difficult to recover from the fields and will be polluted by a vast amount of organic material and sand, making efficient recycling and even combustion with energy recovery extremely costly and not attractive.   
  
a number of agrotextiles are based on natural fibres, but in general these products are degrading that fast in the natural environment that there lifetime is usually limited to one or maximum two years and textiles with a relatively high weight per mâ² are required in order to compensate a bit for the fast degradation.   
  
2.2 objectives   
  
the bioagrotex projects aims at the development of fully biobased agrotextiles with a controlled (or extended) durability as alternatives for the existing pp based agrotextiles or the natural fibre based agrotextiles with a very short lifetime.   
  
two routes are followed:  
  
1. the development of biopolymers formulations (wp1) that can be melt-processed using a range of textile extrusion techniques including tape or monofilament, staple fibre, multifilament extrusion on laboratory and pilot scale (wp2) and on industrial scale including a range of further industrial processing trials such as knitting, weaving, needlefelt production (wp6).  
  
two biopolymer families are evaluated:  
a. use of biopolyesters as meltprocessable polymers, with focus on pla   
b. use of starch based formulations   
  
2. development of natural fibres, either recycled or from low value agricultural fractions and optimising properties via (enzymatic) pretreatment to optimise yield and properties (wp4). development of bioresin (furan based) to finish the nf based products, extending the durability without jeopardizing the mechanical properties (wp3), processing the experimental fibres into non-woven structures and finishing them on pilot scale (wp5) and upscaling further to fully integrated industrial processes (wp6).  
  
both routes are supported by biodegradation tests on labscale and via field tests and detailed chemical analysis of the degradation routes (wp7) along with the evaluation of the ecological impact (lca) and the possible ecotoxicity trials.  
  
the developed production routes will be used to produce at industrial scale demonstrators to be installed in centralised field tests allowing the evaluation of the relevant performances of the developed products. (wp8). further supportive wps are foreseen including training and dissemination (wp9), ipr and knowledge management and exploitation policy (wp10), project management (wp11).  
  
based on this approach the following specific objectives were defined at the start of the project:  
  
a: for the thermoplastic biopolymer formulations:  
- the definition of optimised starch based formulations, that can be processed on standard textile extrusion equipment to fibres, mono- or multifilaments with acceptable mechanical and processing properties,  
- the definition of optimised biopolyester (pla) based formulations, that can be processed on standard textile extrusion equipment to fibres, mono- or multifilaments with acceptable mechanical and processing properties,  
- selected range of additives to optimise processability of the biopolymer formulations and to integrate specific properties  
- to define routes to vary the (bio)degradability and lifetime of end products  
- optimised industrial extrusion processes, with output similar to production processes with standard polymers.   
  
b: for the natural fibres   
- defining alternative sources of natural fibres based on agricultural wastes or low value side products  
- development of ecological relevant (enzymatic) preparation routes to extract fibres with optimal yield and properties, including raised hydrophilicity  
- defined processing routes for pure or blended natural fibre materials into qualitative nonwovens  
  
c: for the biobased resins with preservation activity.  
- realisation of fully biobased water dilutable resins,  
- realisations of resins with increased reactivity allowing complete curing at acceptable temperature (max 180â°c) and within 2 to 3 minutes time.   
- optimised resin formulation that doesnât alter the mechanical properties such as stiffness or drapability  
- bioresin with high preservation action that at minimum doubles the expected lifetime of the natural fibres based ground-covers.   
- routes for industrial application of the bioresins in combination with specific functionalities  
- realisation of natural fibre based groundcovers with a reduction in weight/mâ² of up to 50%.  
- realisation of natural fibre based groundcovers with an extended (min doubled) lifetime   
  
d: realisation of demonstrators and pre-commercial products  
- developed industrial production routes for thermoplastic and natural fibres and formulations via standard textile processing techniques including weaving, knitting, non-woven production, needlefelt production - realisation of at minimum 4 demonstrator products covering the different development routes and product types defined.  
  
possible demonstrator models are:  
-knitted biopolymer cloth for covering crops: creating micro-climate and crop protection against insects applied either out-door or in green houses, requested life time: 1 up to 3 seasons; limited degradation under standard conditions of use, compostable   
-biopolymer based non-woven groundcovers: support for natural grass mats: to be applied in the earth strengthening the turf and/or stabilising slopes, should retain its properties during 1 up to 5 years; slow degradation under 'soil burial test'- fast degradation under composting,   
-biopolymer based woven groundcovers (prevention of weed growth and use of herbicides, support the water housekeeping of the ground) stability during minimum 3 to 5 years, fast degradation under composting conditions  
-natural fibre based groundcovers for out-door use, weed prevention improved water housekeeping, with an extended lifetime (up to three years) due to the application of bioresins with preservation action  
-other possible domains for implementation:  
natural fibres or biopolymer based agrotextiles for applications in green-houses, sun-screens, limitation of heat-loss, light reflection, â durability minimum five years under high temperature and high humidity conditions  
  
alternative out-door application (nets for bird protection, hail protection or sunscreens) minimum durability five years under high uv conditions.  
  
e. scientific proof of enhanced properties and ecological aspects of the development.   
detailed analysis of all generated materials, both on performance and ecological impacts are foreseen in order to proof the potential and the ecological relevance of the development.  
  
the following core evaluations are defined.  
- lab scale durability testing, via different routes simulating different routes of degradation  
 soil- burial test (aatcc 30-2004) resistance to biodegradation (resisting minimum 56 days, doubling the durability of standard nf based groundcovers)  
 q-uv tests: resistance against uv light (min 1500 hours)  
 combined q-uv and soil burial tests  
 hydrolysis tests under extreme conditions  
 analysis of mechanical properties and molecular weight as function of durability tests  
 lab scale composting tests; industrial conditions  
- real life testing via locally installed agrotextiles and via demonstrator field tests for a minimum period of 1 year.   
- ecotoxicity tests on the developed materials and after composting; to ascertain the possibility of implementation without creating toxicological side effects.   
- detailed lca analysis taken into account, production, use and end-of-life solutions for the newly developed end-products.   
  
based on the realisation of these objectives and on the created knowledge base regarding interaction of product parameters, processing conditions, functional additives and durability properties it should be feasible to bring at least some of the demonstrator products to the market within short term after finalisation of the project. the generated know-how should allow via further industrial developments the creation of a large range of different agrotextiles. the results obtained could be valorised further in other application fields such as textiles, composites, injection moulded articles and can therefore contribute to some extent to the overall development of the biobased economy.  
  
2.3 defined workplan.  
  
for the realisation of these objectives a multidisciplinary approach is required covering the complete production chain - starting with the development of the biopolymers up to the final textile products. at the same time the project has to pass through all stages within the innovation process; starting with fundamental research aspects, through implementation and up-scaling development of adapted testing procedures and even providing complete proof of concept via full-scale and real life demonstrators.  
  
the structure of the workplan and the interactions between work packages are highlighted in the project scheme:   
  
project results:  
3 a description of the main science and technology (s&t) results/foregrounds  
  
along the four year project a multitude of results are obtained in the different research domains. results are not reported per wp since some of the wp closely interacts with one another and are evaluating the same products or processes along the production chain: formulation, processing lab scale, processing industrial scale, definition of end products. due to constant feed-back and fed-forward along this chain it's better to report the results per individual development topic.  
  
results are therefore grouped together under the following topics:  
- results related to starch based formulations and processability to textile yarns.  
- results related to the formulations, processability and properties of biopolyesters.   
- observations on fast degrading pla materials and problem solving.  
- alternative natural fibre sources and processing into non-wovens  
- development of biobased resins and application to natural fibre structures   
- demonstrator development and demonstrator field tests  
- durability and ecological aspects of the developed products.  
  
3.1 results related to starch based formulations and processability to textile yarns.  
  
for the starch based biopolymer formulations a range of applications are already known. at present it is these type of biopolymer formulations that have the largest share in the biopolymer market based. the applications are at present however predominantly in (food) packaging applications, film extrusion and to some extent injection moulding applications. in these applications the fast biodegradability of the products offers a major advantage. since starch itself has very poor thermoplastic properties, it cannot be processed as such and always needs plasticizing and blending with other biodegradable polymers. popular polymers for blending are amongst others the oil based polycaprolacton, and ethylenevinylacetate or biopolymers such as pla. development of textiles made of starch based formulations is in its infancy and no commercial products were known at the start of the project.   
  
the objective within bioagrotex is that starch based formulations are developed that can be processed into the different textile products: tapes or monofilament and if possible multifilament. a minimum level of mechanical properties (tenacity level of 0.2 n/tex) should be reached in order that the products can be processed further.   
  
as a starting point standard solanyl formulations, basically used for film extrusion, were selected for first small scale textile extrusion trials. it was observed that these were totally inadequate for the textile processing route. inappropriate stability and melt strength was observed. either no filament structures could be obtained or only filaments could be produced without applying a cold drawing step and therefore resulting in a very brittle product.   
  
it was concluded that the formulations needed adaptations and the following elements were taken into consideration:   
- intensification of the compounding process: - leading to a finer distribution of the polymer components in one another, this is observed but deblending limits the efficiency.  
- adapting water content during extrusion; - water can have a positive plastisizing effect but also catalyses degradation and hydrolysis. in combination with (bio)polyesters the water content should be kept low.   
- lowering the extrusion temperature - as low as possible (â± 160â°c) - in order to avoid degradation of starch and the hydrolysis of other biopolymer components.   
- evaluation of different blend compositions and ratioâs. â raised compatibility between materials influences in a positive way the fineness of blend morphology and reduces deblending effects. a higher % of thermoplastic polymers improves processability, but final 'starch' content will become low.   
- selection of high molecular weight grade of the added thermoplastic polymer (pla) â a considerable improvement in melt strength and therefore processability and stability was observed.   
  
3.2 results related to the formulation, processability and properties of biopolyesters.  
  
pla is one of the biopolymers available in the market for a longer time, at considerable volume (greater than 100kton) and acceptable price. the implementation is especially known in packaging applications and to a lesser extent for textiles or injection moulding. although the first products are proposed a long route of developments still is needed to bring the biopolymer formulations and the processability to a similar level as the petrochemical based ones.   
  
within the bioagrotex project the developments on the biopolyesters formulations are specific aiming at increasing the mechanical properties (tenacity and elongation at break, and reduction of brittleness), increase in processability (operating window at different process lines, production speed), improvement in processing stability (influence of temperature and humidity) and integrating functionalities in the biopolymer formulation. in addition the formulations are function of the different extrusion routes required for the different types of textile intermediates: tapes, monofils, staple fibre, fdy or poy.  
  
for the different processes different pilot and industrial extrusion systems are used to explore the processability. the different lines have different configurations that have important consequences on the polymer requirements and processing conditions. one can differentiate between the following extrusion systems:  
  
a. monofilament or tape extrusion line.  
this type of extrusion equipment is used for production of thicker textile monofilaments or tape material. due to the diameter of the produced filaments more cooling is required and this is provided by quenching the melt coming from the extruder directly in a water bath. as an alternative the melt can also be deposited on a metal quench roll (internally cooled). after cooling the yarn is monofilament is heated again and drawn to a high degree (factor 5 to 12) in order that the polymer chains are stretched to the maximum and the material receives its highest tensile properties possible. this process is in general performed at a limited speed (100 a 200 m/min). the products produced via this route are amongst others used in knitted agrotextiles using monofilaments or tape production for production of woven tape fabrics.   
  
b. poy extrusion â separate draw (texturation) step.  
fine filament yarns or staple extrusion is in general performed via air-quenching instead of water bath quenching. the production speeds are considerably higher (3000 up to greater than 5000 m/min) and spinerettes are much finer, making the process more critical. especially the rheology of processed materials becomes more critical) (less viscous formulations required) as well as the fineness of any additives used should be below a few âµm in order not to block filters or to disturb the built-up of mechanical properties.   
  
moreover the poy production process is a two stage process. in the first stage extrusion of the filaments take place at a high speed without a secondary drawing. due to the high meltdrawing ratio the filaments produced gets already an important degree of orientation and therefore stability and tenacity. nevertheless the yarn is still only a partly oriented yarn and will need a secondary drawing step to obtain it's full mechanical properties and stability. this two-step production process is especially explored for the production of very fine multifilaments, which can be used in knitted crop protection products.  
  
c. fdy extrusion â integrated drawing step.  
a second production method to produce fine filament yarns is the extrusion with integrated drawing resulting in a full drawn yarn in one production step. depending on the process, 1, 2 or even 3 stage drawings are possible. not only multifilament yarns are produced in this way but as well staple fibre production. in that final case also texturation and cutting the yarn to the appropriate length are integrated in the same process.   
  
e. formulation routes or pla based materials.   
formulation routes explored are related to:   
- initial polymer grades; varying in molecular weight, d lactic acid content (homogeneity and crystallinity) â a high mw contributes to a raised melt strength and processability and is needed to reach a higher tenacity level in the textile products. a few % d-lactic monomer content contributes to the flexibility of the products and reduces the brittleness but at higher percentages the melt temperature and the overall polymer properties are reduced too much.  
- addition of 'poly d lactide content': a special crystal structure is generated when a fraction of poly d la is blended in the polyl la with a higher melting point (greater than 200 â°c). the highest effects are expected at 50/50 blend ratio, but also at lower % of added poly d la effects can be obtained. the addition contributes to a higher thermal stability of the extruded monofilaments or tapes but little effect on tenacity is observed. due to the limited availability and higher price of the poly d la polymer, this route of formulation is of interest for future industrial developments.  
- incorporation of low% of other biopolymers (pha), - can contribute to an improved processability and has an impact on draw ratio and resulting mechanical properties especially in air quenched production. effects are variable in function of the processing routes and should be evaluated for specific end applications.   
- addition of impact modifiers and crystallisation agents â in most cases products seems to have only minor effect on the extrusion process or on the strength of the textiles produced, but crystallisation and recrystallisation behaviour is clearly influenced, contributing to textile intermediates with a raised stability. use of these types off additives can be considered in these processes where fast crystallisation is required.   
- control of humidity content: during melt processing partial hydrolysis of pla will occur as function of humidity content, residence time and process temperature. predrying of polymers to below 250 ppm is in general sufficient to avoid detrimental effects during the processing. proccesing of formulations with higher water content, will lead to uncontrolled shifts in polymer properties.   
- use of chain extenders: chain extenders can have a positive effect on molecular weight of the biopolymer. they can contribute to reduction of the hydrolysis effect created by processing biopolyesters with a too high humidity content (or the required level of predrying) and can improve properties and processability by counteracting the polymer hydrolysis.  
  
an interesting side-effect is observed namely increase of dyeability; although less important for agrotextiles this can have important benefits in other application area's such as clothing.  
  
- use of biodegradation promoters â it is possible to add low amounts of a biodegradation promotor during the extrusion. concentration must be low and processing conditions must be kept well under control to limit the impact on hydrolysis and lower tenacity during extrusion. the products show clearly a much faster degradation during further durability testing, especially q-uv artificial weathering tests, than reference products. this can be of importance for applications where a reduced lifetime is required even without entering industrial composting conditions.  
- use of hydrolytical stabilisers â pla is vulnerable to hydrolysis at high temperature e.g. 80â°c and high humidity degree. within one or two days at these extreme conditions the polymer loses its mechanical properties and the molecular weight drops drastically. it could be proven that using selected hydrolysis stabilisers under correct processing conditions will largely stop the hydrolysis process. the additive stabilises as well the melt during the melt processing stage although it is still to be advised to dry the material well before processing.   
  
3.3 observations on fast degrading pla materials and problem solving.  
in the course of the project two difficulties were observed for instabilities of the extruded pla textile materials:   
- shift in mechanical properties due to reorientation and crystallisation process  
- decay in mechanical properties under warehouse conditions.   
  
3.3.1 shift in mechanical properties due to reorientation and crystallisation process.  
  
pla is a polymer that in general crystallizes only slowly. this can create some problems during processing.  
  
if insufficient crystallisation takes place during the extrusion process, the material will further post-crystallise after the production process, whether or not accelerated by heat treatment. in the example shown above crystallisation in a poy extrusion was so low that after winding, the post crystallisation process caused such an increase in temperature and in tension that the bobbin was destroyed completely. in most cases the effects are not that spectacular but shifts in mechanical properties of 10 to 20% can be observed in a number of cases if insufficient crystallisation on the extrusion line is obtained.   
  
the experiences led to the following rules of thumb to optimise crystallisation of pla yarns.   
  
achievement of high crystallinity and therefore high stability of mechanical properties after processing will be obtained by:   
- application of low cooling rate during melt drawing,  
- increased melt-drawing ratio  
- additional support of crystallisation by  
â stress (winding speed, draw ratio)  
â nucleating additives  
- application of secondary drawing (drawing on hot godets or oven)  
- multistep drawing   
- heat treatment of yarns: high setting temperatures.   
  
3.3.2 stabilisation of pla against hydrolysis.   
although pla is stable under standard conditions, it is easily hydrolysed at high humidity and high temperature. within about 3 days the polymer loses its properties at 80â°c and 80% rel. humidity. although such extreme conditions are not occurring during real life of agrotextiles, it is still of interest to be able to stop this process.   
specialty hydrolytical stabilisers additives were evaluated and found that not only stop the hydrolysis at the extreme storage conditions but also inhibits the hydrolysis during melt processing.  
  
3.3.3 decay in mechanical properties under warehouse conditions.  
  
during the project it was observed in a few cases that pla materials that normally should have a high stability and should not lose their mechanical properties under 'warehouse conditions' over years started to degrade very fast. the drop in properties can occur in a few weeks to a few months' time and is totally unacceptable for commercial applications. other materials produced under similar conditions stayed intact for several years. the phenomenon was analysed in great details.  
  
it was observed that the direct cause of the problem is related to the growth of fungi on the material as could be observed by microscopical analyisis and microbiological tests.   
  
3.4 alternative natural fibre sources and processing into non-wovens.  
  
3.4.1 alternative natural fibre sources and upgrading of properties.  
also natural fibres are used in the development of agrotextiles. hereby the project is focusing on nf sources either obtained via recycling, as a waste or side fraction of agricultural crops or products with a high agricultural output.  
  
main nf sources evaluated are recycled jute, linseed flax, hemp, hop wastes and nettle.   
  
it was shown that hops or nettle offer no economical interesting source due to the very low fibre yield generated from these materials. linseed and hemp offer good potential to generate fibres with high yield and good properties.   
  
hemp and linseed fibre fractions offer good potential to be used for technical fibre applications including agrotextiles.   
  
also hydrophilicity of fibre material is increased, facilitating further impregnating processing to improve homogeneity in finishing processes.  
  
the field retting system developed can be considered for industrial exploitation for natural fibre production whether or not for agrotextile applications. the evaluated natural fibre sources have a better quality than the recycled jute, but price of these alternative sources is still higher due to the required processing. price level is still acceptable for the application envisaged, as far as transport costs are not increasing price too much.  
  
3.4.2 alternative natural fibres and processing properties for non-woven production.  
  
the processibility of the different natural fibre sources into needle felts - pure or in blends of different ratio's â were evaluated on pilot and industrial lines.   
  
3.4.3 evaluation of hydrophilicity via moisture management tester.   
  
to evaluate the interaction with water, a new test method of 3d moisture spreading through the agrotextile structure was developed by use of the mmt-sdl device. the mmt was developed to measure dynamic liquid transport properties of plain textile substrates.  
  
moisture management is a method to characterize the 3d liquid transport properties of fabrics. spread of solution applied on the top side of textile substrate during its penetration through the textile structure is electronically detected.   
  
the limits regarding weight and fabric thickness, and test conditions (prolonged time and testing liquor dose) were studied to facilitate measurements of actual agromat constructions of different weight. this improvement of methodology facilitated the evaluation of the samples processed using bioresins, enzyme treatment, and measuring the water transmission and suction behaviour as shown in the samples below.  
  
it can be concluded that short fibre qualities:  
- linseed fibre with the growing potential of nutrient production waste  
- hemp as an alternative short bast fibre   
can be identified as potential, effective sources. positive efficiency of the new enzymatic process â preferably its field spray alternative (called 'bio-retting') was confirmed by repeated seasonal post-harvest trials. special inotex enzymatic product (texazym ser 7 conc.) developed and tested in real field conditions. common and enzymatic modified fibres were tested in pilot scale production of needle punch carded nonwovens. no significant differences and limitations by process-ability of various blend combinations observed.   
  
3.5 development of biobased resins and application to natural fibre structures  
  
3.5.1 development of bioresin formulations  
  
for the development of the bioresins it was shown in an early stage that the furan bioresins are offering an increased biostability to the natural fibres they are applied to.  
  
the treated textiles showed however disadvantages including a limited reactivity, long and harsh processing and high stiffness. therefore the following optimisation routes were explored:  
- increase of reactivity - to reduce curing temperature and time to be compatible with the application process on natural fibres, reactivity increased via adapting functional groups and catalytic system.  
- development of water dilutable furan formulation with high water content, to allow a more homogeneous application with reduced resin content.  
- reduction of brittleness and hardness after curing via:   
development of alternative reactive monomers with longer aliphatic side chains; feasibility was tested but offers only potential at long term, due to the complex chemistry,   
 blending with long chain fatty acid esters â increase in flexibility, remaining fully biobased.  
- optimisation of stability and anti-foaming via addition of the appropriate agents.   
  
a novel hybrid biorezâ® formulation was developed taken these elements into account and resulting in a fully biobased, water dilutable and stable thermoset reactive ...

# BIOAGROTEX

Project Acronym: BIOAGROTEX

programme & topic: FP7-NMP NMP-2007-4.0-2

Most frequent returning words in objectives:

* ('properties', 45)
* ('products', 31)
* ('processing', 30)
* ('production', 29)
* ('fibre', 28)
* ('extrusion', 27)
* ('formulations', 25)
* ('process', 24)
* ('conditions', 22)
* ('development', 22)
* ('fibres', 19)
* ('routes', 19)
* ('textile', 19)
* ('agrotextiles', 17)
* ('developed', 16)
* ('biopolymer', 15)
* ('application', 14)
* ('tests', 14)
* ('processability', 14)
* ('project', 14)
* ('water', 14)
* ('durability', 13)
* ('applications', 13)
* ('materials', 13)

executive summary:  
  
increasing oil-prices, a growing threat of oil-shortages, greenhouse gases and their effect on climate change, are elements that contribute to the concern for the future of our oil based economy. the search for biobased polymers and a more extensive use of the natural resources will be needed to cope with these problems and to initiate growth in the biobased economy. agrotextiles can offer a very attractive end market in this regard. at the moment the market is dominated by polyolefin' based agrotextiles. other products are based on natural fibres but are degraded too fast to be very attractive. bioagrotex aims at developing novel fully biobased agrotextiles with a drastically reduced impact on environment.   
  
different production routes are followed to develop this type of end product.  
  
in a first route standard natural fibre based groundcovers are upgraded via application of bioresins including functional additives. for the natural fibres either recycled or upgraded side fractions of linseed or hemp production can be used. properties of these fibre fractions are improved by optimising the fibre preparation process, including enzymatic retting or pretreatment. upgrading the durability is performed via furan based bioresins specially developed for this application in order to control reactivity of the resin and the flexibility of the woven or non-woven fibre mats. an alternative route using partly oil based chemicals is developed as well with included functionality to delay degradation. it is shown in lab trials using soil burial and q-uv tests along with field trials that the developed products have a considerable extended lifetime in normal usage (greater than double).  
  
in a second route melt processable biopolymer formulations either starch based or pla based are evaluated for their potential in textile extrusion processes including: staple fibre, monofilament yarns, multifilament yarns and tapes. processes are optimised to obtain the appropriate properties.   
  
the objective to use starch based thermoplastic in these applications couldn't be reached. improved formulations were developed that allows producing monofilaments, multifilaments and tapes, but mechanical properties are still insufficient for developing industrial products.  
  
with pla based formulations the complete range of textiles can be produced with acceptable properties for further processing, including production of non-wovens, knitted and woven fabrics. also a range of functionalization routes either to improve processability and properties, to control or improve the durability of the products and to introduce specific functionalities like: colour, flame retardancy and anti-microbial properties. also durability of these materials is tested in laboratory conditions and in real life leading to an expected life time of at least three to five years.   
  
project context and objectives:  
  
2 summary description of project context and objectives   
  
2.1 context  
  
increasing oil-prices, a growing threat of oil-shortages, kyoto agreements on greenhouse gases, environmental effects and climate changes, are all elements that contribute to the concern for the future of our oil based economy. europe is gradually preparing the shift towards a biobased economy, a multistep process that will take decennia to come to its completion. initiatives are required to start-up this process of change and to explore at an early stage the possibilities offered by products already under development.   
  
textiles and especially agrotextiles offer a very attractive end market. volumes in this market area are high and fast growing. at present, products are mainly based on polyolefinâs (greater than 200ktonnes/annum in europe) and to a lesser extent other petrochemical polymers such as pa and pet are used. in most cases these agrotextiles are at the end-of-life difficult to recover from the fields and will be polluted by a vast amount of organic material and sand, making efficient recycling and even combustion with energy recovery extremely costly and not attractive.   
  
a number of agrotextiles are based on natural fibres, but in general these products are degrading that fast in the natural environment that there lifetime is usually limited to one or maximum two years and textiles with a relatively high weight per mâ² are required in order to compensate a bit for the fast degradation.   
  
2.2 objectives   
  
the bioagrotex projects aims at the development of fully biobased agrotextiles with a controlled (or extended) durability as alternatives for the existing pp based agrotextiles or the natural fibre based agrotextiles with a very short lifetime.   
  
two routes are followed:  
  
1. the development of biopolymers formulations (wp1) that can be melt-processed using a range of textile extrusion techniques including tape or monofilament, staple fibre, multifilament extrusion on laboratory and pilot scale (wp2) and on industrial scale including a range of further industrial processing trials such as knitting, weaving, needlefelt production (wp6).  
  
two biopolymer families are evaluated:  
a. use of biopolyesters as meltprocessable polymers, with focus on pla   
b. use of starch based formulations   
  
2. development of natural fibres, either recycled or from low value agricultural fractions and optimising properties via (enzymatic) pretreatment to optimise yield and properties (wp4). development of bioresin (furan based) to finish the nf based products, extending the durability without jeopardizing the mechanical properties (wp3), processing the experimental fibres into non-woven structures and finishing them on pilot scale (wp5) and upscaling further to fully integrated industrial processes (wp6).  
  
both routes are supported by biodegradation tests on labscale and via field tests and detailed chemical analysis of the degradation routes (wp7) along with the evaluation of the ecological impact (lca) and the possible ecotoxicity trials.  
  
the developed production routes will be used to produce at industrial scale demonstrators to be installed in centralised field tests allowing the evaluation of the relevant performances of the developed products. (wp8). further supportive wps are foreseen including training and dissemination (wp9), ipr and knowledge management and exploitation policy (wp10), project management (wp11).  
  
based on this approach the following specific objectives were defined at the start of the project:  
  
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- realisation of fully biobased water dilutable resins,  
- realisations of resins with increased reactivity allowing complete curing at acceptable temperature (max 180â°c) and within 2 to 3 minutes time.   
- optimised resin formulation that doesnât alter the mechanical properties such as stiffness or drapability  
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-knitted biopolymer cloth for covering crops: creating micro-climate and crop protection against insects applied either out-door or in green houses, requested life time: 1 up to 3 seasons; limited degradation under standard conditions of use, compostable   
-biopolymer based non-woven groundcovers: support for natural grass mats: to be applied in the earth strengthening the turf and/or stabilising slopes, should retain its properties during 1 up to 5 years; slow degradation under 'soil burial test'- fast degradation under composting,   
-biopolymer based woven groundcovers (prevention of weed growth and use of herbicides, support the water housekeeping of the ground) stability during minimum 3 to 5 years, fast degradation under composting conditions  
-natural fibre based groundcovers for out-door use, weed prevention improved water housekeeping, with an extended lifetime (up to three years) due to the application of bioresins with preservation action  
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 soil- burial test (aatcc 30-2004) resistance to biodegradation (resisting minimum 56 days, doubling the durability of standard nf based groundcovers)  
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- ecotoxicity tests on the developed materials and after composting; to ascertain the possibility of implementation without creating toxicological side effects.   
- detailed lca analysis taken into account, production, use and end-of-life solutions for the newly developed end-products.   
  
based on the realisation of these objectives and on the created knowledge base regarding interaction of product parameters, processing conditions, functional additives and durability properties it should be feasible to bring at least some of the demonstrator products to the market within short term after finalisation of the project. the generated know-how should allow via further industrial developments the creation of a large range of different agrotextiles. the results obtained could be valorised further in other application fields such as textiles, composites, injection moulded articles and can therefore contribute to some extent to the overall development of the biobased economy.  
  
2.3 defined workplan.  
  
for the realisation of these objectives a multidisciplinary approach is required covering the complete production chain - starting with the development of the biopolymers up to the final textile products. at the same time the project has to pass through all stages within the innovation process; starting with fundamental research aspects, through implementation and up-scaling development of adapted testing procedures and even providing complete proof of concept via full-scale and real life demonstrators.  
  
the structure of the workplan and the interactions between work packages are highlighted in the project scheme:   
  
project results:  
3 a description of the main science and technology (s&t) results/foregrounds  
  
along the four year project a multitude of results are obtained in the different research domains. results are not reported per wp since some of the wp closely interacts with one another and are evaluating the same products or processes along the production chain: formulation, processing lab scale, processing industrial scale, definition of end products. due to constant feed-back and fed-forward along this chain it's better to report the results per individual development topic.  
  
results are therefore grouped together under the following topics:  
- results related to starch based formulations and processability to textile yarns.  
- results related to the formulations, processability and properties of biopolyesters.   
- observations on fast degrading pla materials and problem solving.  
- alternative natural fibre sources and processing into non-wovens  
- development of biobased resins and application to natural fibre structures   
- demonstrator development and demonstrator field tests  
- durability and ecological aspects of the developed products.  
  
3.1 results related to starch based formulations and processability to textile yarns.  
  
for the starch based biopolymer formulations a range of applications are already known. at present it is these type of biopolymer formulations that have the largest share in the biopolymer market based. the applications are at present however predominantly in (food) packaging applications, film extrusion and to some extent injection moulding applications. in these applications the fast biodegradability of the products offers a major advantage. since starch itself has very poor thermoplastic properties, it cannot be processed as such and always needs plasticizing and blending with other biodegradable polymers. popular polymers for blending are amongst others the oil based polycaprolacton, and ethylenevinylacetate or biopolymers such as pla. development of textiles made of starch based formulations is in its infancy and no commercial products were known at the start of the project.   
  
the objective within bioagrotex is that starch based formulations are developed that can be processed into the different textile products: tapes or monofilament and if possible multifilament. a minimum level of mechanical properties (tenacity level of 0.2 n/tex) should be reached in order that the products can be processed further.   
  
as a starting point standard solanyl formulations, basically used for film extrusion, were selected for first small scale textile extrusion trials. it was observed that these were totally inadequate for the textile processing route. inappropriate stability and melt strength was observed. either no filament structures could be obtained or only filaments could be produced without applying a cold drawing step and therefore resulting in a very brittle product.   
  
it was concluded that the formulations needed adaptations and the following elements were taken into consideration:   
- intensification of the compounding process: - leading to a finer distribution of the polymer components in one another, this is observed but deblending limits the efficiency.  
- adapting water content during extrusion; - water can have a positive plastisizing effect but also catalyses degradation and hydrolysis. in combination with (bio)polyesters the water content should be kept low.   
- lowering the extrusion temperature - as low as possible (â± 160â°c) - in order to avoid degradation of starch and the hydrolysis of other biopolymer components.   
- evaluation of different blend compositions and ratioâs. â raised compatibility between materials influences in a positive way the fineness of blend morphology and reduces deblending effects. a higher % of thermoplastic polymers improves processability, but final 'starch' content will become low.   
- selection of high molecular weight grade of the added thermoplastic polymer (pla) â a considerable improvement in melt strength and therefore processability and stability was observed.   
  
3.2 results related to the formulation, processability and properties of biopolyesters.  
  
pla is one of the biopolymers available in the market for a longer time, at considerable volume (greater than 100kton) and acceptable price. the implementation is especially known in packaging applications and to a lesser extent for textiles or injection moulding. although the first products are proposed a long route of developments still is needed to bring the biopolymer formulations and the processability to a similar level as the petrochemical based ones.   
  
within the bioagrotex project the developments on the biopolyesters formulations are specific aiming at increasing the mechanical properties (tenacity and elongation at break, and reduction of brittleness), increase in processability (operating window at different process lines, production speed), improvement in processing stability (influence of temperature and humidity) and integrating functionalities in the biopolymer formulation. in addition the formulations are function of the different extrusion routes required for the different types of textile intermediates: tapes, monofils, staple fibre, fdy or poy.  
  
for the different processes different pilot and industrial extrusion systems are used to explore the processability. the different lines have different configurations that have important consequences on the polymer requirements and processing conditions. one can differentiate between the following extrusion systems:  
  
a. monofilament or tape extrusion line.  
this type of extrusion equipment is used for production of thicker textile monofilaments or tape material. due to the diameter of the produced filaments more cooling is required and this is provided by quenching the melt coming from the extruder directly in a water bath. as an alternative the melt can also be deposited on a metal quench roll (internally cooled). after cooling the yarn is monofilament is heated again and drawn to a high degree (factor 5 to 12) in order that the polymer chains are stretched to the maximum and the material receives its highest tensile properties possible. this process is in general performed at a limited speed (100 a 200 m/min). the products produced via this route are amongst others used in knitted agrotextiles using monofilaments or tape production for production of woven tape fabrics.   
  
b. poy extrusion â separate draw (texturation) step.  
fine filament yarns or staple extrusion is in general performed via air-quenching instead of water bath quenching. the production speeds are considerably higher (3000 up to greater than 5000 m/min) and spinerettes are much finer, making the process more critical. especially the rheology of processed materials becomes more critical) (less viscous formulations required) as well as the fineness of any additives used should be below a few âµm in order not to block filters or to disturb the built-up of mechanical properties.   
  
moreover the poy production process is a two stage process. in the first stage extrusion of the filaments take place at a high speed without a secondary drawing. due to the high meltdrawing ratio the filaments produced gets already an important degree of orientation and therefore stability and tenacity. nevertheless the yarn is still only a partly oriented yarn and will need a secondary drawing step to obtain it's full mechanical properties and stability. this two-step production process is especially explored for the production of very fine multifilaments, which can be used in knitted crop protection products.  
  
c. fdy extrusion â integrated drawing step.  
a second production method to produce fine filament yarns is the extrusion with integrated drawing resulting in a full drawn yarn in one production step. depending on the process, 1, 2 or even 3 stage drawings are possible. not only multifilament yarns are produced in this way but as well staple fibre production. in that final case also texturation and cutting the yarn to the appropriate length are integrated in the same process.   
  
e. formulation routes or pla based materials.   
formulation routes explored are related to:   
- initial polymer grades; varying in molecular weight, d lactic acid content (homogeneity and crystallinity) â a high mw contributes to a raised melt strength and processability and is needed to reach a higher tenacity level in the textile products. a few % d-lactic monomer content contributes to the flexibility of the products and reduces the brittleness but at higher percentages the melt temperature and the overall polymer properties are reduced too much.  
- addition of 'poly d lactide content': a special crystal structure is generated when a fraction of poly d la is blended in the polyl la with a higher melting point (greater than 200 â°c). the highest effects are expected at 50/50 blend ratio, but also at lower % of added poly d la effects can be obtained. the addition contributes to a higher thermal stability of the extruded monofilaments or tapes but little effect on tenacity is observed. due to the limited availability and higher price of the poly d la polymer, this route of formulation is of interest for future industrial developments.  
- incorporation of low% of other biopolymers (pha), - can contribute to an improved processability and has an impact on draw ratio and resulting mechanical properties especially in air quenched production. effects are variable in function of the processing routes and should be evaluated for specific end applications.   
- addition of impact modifiers and crystallisation agents â in most cases products seems to have only minor effect on the extrusion process or on the strength of the textiles produced, but crystallisation and recrystallisation behaviour is clearly influenced, contributing to textile intermediates with a raised stability. use of these types off additives can be considered in these processes where fast crystallisation is required.   
- control of humidity content: during melt processing partial hydrolysis of pla will occur as function of humidity content, residence time and process temperature. predrying of polymers to below 250 ppm is in general sufficient to avoid detrimental effects during the processing. proccesing of formulations with higher water content, will lead to uncontrolled shifts in polymer properties.   
- use of chain extenders: chain extenders can have a positive effect on molecular weight of the biopolymer. they can contribute to reduction of the hydrolysis effect created by processing biopolyesters with a too high humidity content (or the required level of predrying) and can improve properties and processability by counteracting the polymer hydrolysis.  
  
an interesting side-effect is observed namely increase of dyeability; although less important for agrotextiles this can have important benefits in other application area's such as clothing.  
  
- use of biodegradation promoters â it is possible to add low amounts of a biodegradation promotor during the extrusion. concentration must be low and processing conditions must be kept well under control to limit the impact on hydrolysis and lower tenacity during extrusion. the products show clearly a much faster degradation during further durability testing, especially q-uv artificial weathering tests, than reference products. this can be of importance for applications where a reduced lifetime is required even without entering industrial composting conditions.  
- use of hydrolytical stabilisers â pla is vulnerable to hydrolysis at high temperature e.g. 80â°c and high humidity degree. within one or two days at these extreme conditions the polymer loses its mechanical properties and the molecular weight drops drastically. it could be proven that using selected hydrolysis stabilisers under correct processing conditions will largely stop the hydrolysis process. the additive stabilises as well the melt during the melt processing stage although it is still to be advised to dry the material well before processing.   
  
3.3 observations on fast degrading pla materials and problem solving.  
in the course of the project two difficulties were observed for instabilities of the extruded pla textile materials:   
- shift in mechanical properties due to reorientation and crystallisation process  
- decay in mechanical properties under warehouse conditions.   
  
3.3.1 shift in mechanical properties due to reorientation and crystallisation process.  
  
pla is a polymer that in general crystallizes only slowly. this can create some problems during processing.  
  
if insufficient crystallisation takes place during the extrusion process, the material will further post-crystallise after the production process, whether or not accelerated by heat treatment. in the example shown above crystallisation in a poy extrusion was so low that after winding, the post crystallisation process caused such an increase in temperature and in tension that the bobbin was destroyed completely. in most cases the effects are not that spectacular but shifts in mechanical properties of 10 to 20% can be observed in a number of cases if insufficient crystallisation on the extrusion line is obtained.   
  
the experiences led to the following rules of thumb to optimise crystallisation of pla yarns.   
  
achievement of high crystallinity and therefore high stability of mechanical properties after processing will be obtained by:   
- application of low cooling rate during melt drawing,  
- increased melt-drawing ratio  
- additional support of crystallisation by  
â stress (winding speed, draw ratio)  
â nucleating additives  
- application of secondary drawing (drawing on hot godets or oven)  
- multistep drawing   
- heat treatment of yarns: high setting temperatures.   
  
3.3.2 stabilisation of pla against hydrolysis.   
although pla is stable under standard conditions, it is easily hydrolysed at high humidity and high temperature. within about 3 days the polymer loses its properties at 80â°c and 80% rel. humidity. although such extreme conditions are not occurring during real life of agrotextiles, it is still of interest to be able to stop this process.   
specialty hydrolytical stabilisers additives were evaluated and found that not only stop the hydrolysis at the extreme storage conditions but also inhibits the hydrolysis during melt processing.  
  
3.3.3 decay in mechanical properties under warehouse conditions.  
  
during the project it was observed in a few cases that pla materials that normally should have a high stability and should not lose their mechanical properties under 'warehouse conditions' over years started to degrade very fast. the drop in properties can occur in a few weeks to a few months' time and is totally unacceptable for commercial applications. other materials produced under similar conditions stayed intact for several years. the phenomenon was analysed in great details.  
  
it was observed that the direct cause of the problem is related to the growth of fungi on the material as could be observed by microscopical analyisis and microbiological tests.   
  
3.4 alternative natural fibre sources and processing into non-wovens.  
  
3.4.1 alternative natural fibre sources and upgrading of properties.  
also natural fibres are used in the development of agrotextiles. hereby the project is focusing on nf sources either obtained via recycling, as a waste or side fraction of agricultural crops or products with a high agricultural output.  
  
main nf sources evaluated are recycled jute, linseed flax, hemp, hop wastes and nettle.   
  
it was shown that hops or nettle offer no economical interesting source due to the very low fibre yield generated from these materials. linseed and hemp offer good potential to generate fibres with high yield and good properties.   
  
hemp and linseed fibre fractions offer good potential to be used for technical fibre applications including agrotextiles.   
  
also hydrophilicity of fibre material is increased, facilitating further impregnating processing to improve homogeneity in finishing processes.  
  
the field retting system developed can be considered for industrial exploitation for natural fibre production whether or not for agrotextile applications. the evaluated natural fibre sources have a better quality than the recycled jute, but price of these alternative sources is still higher due to the required processing. price level is still acceptable for the application envisaged, as far as transport costs are not increasing price too much.  
  
3.4.2 alternative natural fibres and processing properties for non-woven production.  
  
the processibility of the different natural fibre sources into needle felts - pure or in blends of different ratio's â were evaluated on pilot and industrial lines.   
  
3.4.3 evaluation of hydrophilicity via moisture management tester.   
  
to evaluate the interaction with water, a new test method of 3d moisture spreading through the agrotextile structure was developed by use of the mmt-sdl device. the mmt was developed to measure dynamic liquid transport properties of plain textile substrates.  
  
moisture management is a method to characterize the 3d liquid transport properties of fabrics. spread of solution applied on the top side of textile substrate during its penetration through the textile structure is electronically detected.   
  
the limits regarding weight and fabric thickness, and test conditions (prolonged time and testing liquor dose) were studied to facilitate measurements of actual agromat constructions of different weight. this improvement of methodology facilitated the evaluation of the samples processed using bioresins, enzyme treatment, and measuring the water transmission and suction behaviour as shown in the samples below.  
  
it can be concluded that short fibre qualities:  
- linseed fibre with the growing potential of nutrient production waste  
- hemp as an alternative short bast fibre   
can be identified as potential, effective sources. positive efficiency of the new enzymatic process â preferably its field spray alternative (called 'bio-retting') was confirmed by repeated seasonal post-harvest trials. special inotex enzymatic product (texazym ser 7 conc.) developed and tested in real field conditions. common and enzymatic modified fibres were tested in pilot scale production of needle punch carded nonwovens. no significant differences and limitations by process-ability of various blend combinations observed.   
  
3.5 development of biobased resins and application to natural fibre structures  
  
3.5.1 development of bioresin formulations  
  
for the development of the bioresins it was shown in an early stage that the furan bioresins are offering an increased biostability to the natural fibres they are applied to.  
  
the treated textiles showed however disadvantages including a limited reactivity, long and harsh processing and high stiffness. therefore the following optimisation routes were explored:  
- increase of reactivity - to reduce curing temperature and time to be compatible with the application process on natural fibres, reactivity increased via adapting functional groups and catalytic system.  
- development of water dilutable furan formulation with high water content, to allow a more homogeneous application with reduced resin content.  
- reduction of brittleness and hardness after curing via:   
development of alternative reactive monomers with longer aliphatic side chains; feasibility was tested but offers only potential at long term, due to the complex chemistry,   
 blending with long chain fatty acid esters â increase in flexibility, remaining fully biobased.  
- optimisation of stability and anti-foaming via addition of the appropriate agents.   
  
a novel hybrid biorezâ® formulation was developed taken these elements into account and resulting in a fully biobased, water dilutable and stable thermoset reactive ...

# SHOPINSTANTSHOE

Project Acronym: SHOPINSTANTSHOE

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('footwear', 33)
* ('shape', 23)
* ('memory', 17)
* ('project', 16)
* ('foot', 14)
* ('order', 13)
* ('system', 11)
* ('development', 10)
* ('women', 9)
* ('personalisation', 9)
* ('shop', 9)
* ('leather', 8)
* ('tool', 7)
* ('comfort', 6)
* ('results', 6)
* ('fitting', 5)
* ('material', 5)
* ('textile', 5)
* ('performance', 5)
* ('manufacturing', 5)
* ('dimensions', 5)
* ('process', 5)
* ('service', 4)
* ('developed', 4)

executive summary:   
  
 foot diseases are recognised as a wide societal problem and the large majority of people affected are women. the hallux valgus (commonly known as bunion) is the most frequent foot deformation affecting one every five women in adult age. this pathology along with others such as hammertoes, claw toes, metatarsalgies and ingrown nails take place at the forefoot and are mainly caused by the prolonged use of inadequate footwear (due to the mismatch between foot morphometry and footwear). women fashionable footwear aesthetic constraints demand a more accurate fitting to guarantee footwear functionality and comfort. but differences in human foot morphometry between subjects make really difficult providing an appropriate fitting to each single user, and make women footwear especially uncomfortable and unhealthy. in addition to this, the european footwear industry must identify, assimilate and exploit new technologies to remain competitive as well as develop new concepts, targeting higher added value applications in high-tech areas such as materials and composites. for these reasons, the main objective of this project is the development of a novel, ergonomic, customisable and fashionable women footwear upper and an innovative service providing customers with personalisation of the shoe fitting at the retail shop. furthermore, new biomechanical and fitting customisation criteria will be developed in order to improve the comfort of footwear as well as a new leather-based composite material including shape memory alloys. to achieve these objectives research works will be carried out focused on biomechanic and material and composite fields.   
  
 project context and objectives:   
  
 the 'development of a cost-effective footwear based on shape memory materials to provide an instant fitting personalisation service at the retail shop for enhancing user's comfort' (shopinstantshoe) project has been funded under the european commission (ec)'s seventh framework programme (fp7) in order to develop an aesthetic, innovative, ergonomic, comfortable and customised women footwear. for that purpose, the use of a new material based on textile composites that will include shape memory alloys has been studied. this new footwear concept will improve the comfort of customers, and in some cases, will prevent the appearance of some slight foot pathologies that women normally suffer after a long use of inadequate footwear.   
  
 after this project, calzamedi will set up a new service of women footwear personalisation on retail shops. for that, some basic measurements of the client's feet will be taken in store and, with the aid of a novel last that will have the possibility of adaptation to the client's feet geometry, will allow the configuration of the shoe last modifying the uppers intelligent material.   
  
 in the shopinstantshoe project 7 european partners participated: 3 from spain, institute of biomechanics of valencia (coordinator of the project, valencia), calzamedi (villena) and incusa (valencia), 2 from france, texinov (lyon) and nimesis (strasbourg) and 2 from the united kingdom (uk), surface generation (oakham) and the uk materials technology research institute (melton mowbray).   
  
 project results:   
  
 project results are the following ones:   
  
 (1) a shape memory alloy filament;   
 (2) a shape memory smart textile;   
 (3) a shape memory leather composite;   
 (4) a new personalisation shop tool; and   
 (5) a new customisable footwear upper.   
  
 in order to achieve these results, a research plan has been carried out. the work started with a study of the interaction between the women foot and footwear. it has been performed a review of the most important points and the main dimensional parameters that determine the shape of the foot. all these information has been used for determining the strategy for last personalisation and for obtaining the needed percentage of deformation of the upper material. furthermore, several biocompatibility studies relating human being and shape memory alloys have been gathered in order to assure its suitability for being used in this application.   
  
 relating the development of the shape memory leather composite, a mathematical model has been generated for simulating the behaviour of the new fabric concept, and determining the optimal configuration of its components. after that, a study has been performed in order to optimise the shape memory leather composite. a design of experiments has been done, varying the orientation of the shape memory filaments, the thickness of the intermediate foam, the outer leather and the separation of the filaments inside the textile. this study has been used, on the one hand, to select the optimal configuration of the composite, and on the other hand, to prove the proper performance of the shape memory leather composite before manufacturing the footwear: the composite is able to be deformed, maintains its deformed shape after load is removed, and recover its original shape after applying heat to its surface.   
  
 the shop tool development consisted on three main parts. the first one is relating the development of a new measuring system, able to measure the desired foot parameters of both left and right feet that are needed to personalise the footwear. the second part of the development, is the programming of the software, able to read automatically the foot dimensions provided by the measuring system, able to translate this foot information into last dimensions, and able to control the displacements of the lineal motors in order to achieve the desired last geometry. finally, the last main part of the development has been the shaping system, that is, the part of the shop tool that modifies the footwear geometry. it consists of 10 lineal motors linked to 10 different levers with the shape of the footwears last. the shaping system also includes a heating device, which enables the footwear to recover its original shape.   
  
 regarding the development of the footwear with shape memory properties, several tasks have been performed. first of all, an ergonomic last has been designed in order to fit perfectly a foot with average dimensions. this last geometry is the one used for manufacturing the footwear before being deformed to the customerâs foot dimensions. some design criteria have been generated and applied into other footwear components such as insole, sole, counter, etc., in order to assure a proper biomechanical performance as well as a high level of comfort. after designing all the standard components of footwear, the manufacturing process has been modified in order to include the new shape memory leather composite in the footwear. the footwear including the new composite has the same aesthetic appearance than the standard footwear, being its manufacturing process only slightly modified.   
  
 once the shape memory leather composite, the customisable footwear and the shop tool prototypes were completed, a deep analysis and validation of the system was performed. on the one hand, the performance of the measuring system, of the software and of the shaping system was checked. from this analysis, some recommendations in order to be implemented in the post-project commercial version of the shop tool were gathered. on the other hand, a validation with 15 real users with some special foot pathologies was carried out. test consisted on wearing both the new developed footwear including shape memory textile composite after being personalised to the userâs foot dimensions, and standard footwear for comparison. results show a very high level of comfort using the new developed footwear, although some optimisations are desired in the manufacturing process during the post-project exploitation in order to increase its functional performance.   
  
 potential impact:   
  
 relating strategic issues of the project, the product-service system has been defined, describing the purchase process, a business model approach and a marketing study on the consumer feedback. a strengths, weaknesses, opportunities, and threats (swot) analysis has been also performed in order to detect the strengths, weaknesses, opportunities, and threats of the personalisation process. furthermore, an exploitation plan has been developed including an economic analysis, including different scenarios depending on the number of retail shops interested in the personalisation system, and on the number of pair of footwear sold per season. results demonstrate the economic feasibility of the personalisation system.   
  
 several actions have been performed for disseminating the shopinstantshoe project along the time. the logo and the website of the project (see http://www.instantshoe.com online) were prepared at the first months. a flyer and poster containing basic information of the new personalisation system has been designed and printed. companies of the consortium have showed the poster and distribute flyers in several fairs during the development of the project. articles have been published in magazines (devicemed and revista de biomecã¡nica). three press releases were prepared at the beginning, midterm and end of the project, and were sent to the press media. several magazines, newspaper, television channels, radio channels and websites published some articles, interviews and reports about the project. a total of 61 impacts on different press media have been registered including information of the project.   
  
 the shopinstantshoe project has already finished after 27 months of development. the results are very promising. the technology used for developing the shop tool prototype has been proved, and a composite based on leather with a textile including shape memory alloys has shown the ability to be deformed, as well as to recover its original shape after heating. post-project industrialisation must be performed in order to generate a commercial version of the shop tool, and to optimise the performance of the shape memory properties of the final customisable footwear. after finishing the post-project industrialisation phase, users will benefit from the new footwear customisation service.   
  
 list of websites: http://www.instantshoe.com

# CEREXPRO

Project Acronym: CEREXPRO

programme & topic: FP7-ENERGY ENERGY.2008.8.1.1

Most frequent returning words in objectives:

* ('heat', 43)
* ('process', 30)
* ('number', 28)
* ('structures', 24)
* ('temperature', 22)
* ('burner', 21)
* ('textile', 19)
* ('material', 19)
* ('properties', 17)
* ('nusselt', 17)
* ('surface', 16)
* ('flow', 16)
* ('order', 16)
* ('arrangement', 15)
* ('results', 14)
* ('ifth', 14)
* ('silicon', 13)
* ('loop', 13)
* ('loops', 13)
* ('slurry', 13)
* ('reynolds', 12)
* ('friction', 12)
* ('thermal', 11)
* ('materials', 11)

executive summary:  
  
heat recovery at a high temperature level is essential in industrial thermal processing. the use of ceramic materials yields higher temperatures and subsequently a higher efficiency. the project 'cerexpro' aimed to develop a new generation of ceramic heat exchangers for high temperature heat recovery. the heat exchangers are designed with a highly structured surface. the structuring is increasing the heat transfer on the surfaces of the heat exchangers. this leads to a higher efficiency or a reduction in size of the heat exchangers.  
  
textile materials already incorporating the structuring elements were used as precursors. different fibre materials and textile technologies were tested to obtain three dimensional fabrics. a technical process was developed to transform the textiles into robust, high temperature resistant silicon infiltrated silicon carbide (sisic). the process needed to be adjusted to prevent a collapse of the structures, sufficient yield of ceramic material and to keep the geometric sizes necessary for integration of the ceramics into industrial gas burners. by altering the used polymers the production of solid ceramic structures without significant porosity was possible. the materials derived were intensively tested.   
  
project context and objectives:  
  
industrial production is a major consumer of energy. the energy balance of the eu 27 in 2005 as reported by eurostat shows a total end-energy consumption in the industry sector of more than 13.000 pj representing 28 % of the overall end-energy consumption in all sectors. based on data of the same year for germany (source: german federal ministry of economics and technology) one can asses that ca. 60% of the industrial end-energy use is spent for industrial process heating (total energy consumption in the german industrial sector of 2.550 pj and 1.562 pj for process heat), while more than 80 % of process heat is covered by fossil fuels. assuming that the german distribution is representative and can be extrapolated to the european dimension, a total of more than 6.000 pj are spent for process heat generated by burning of fossil fuels on the european level, representing more than 12% of the total end-energy consumption of eu-27 and at the same time approx. 9.7 % of the total fossil fuel consumption.  
  
consequently, an efficiency increase in process heating of only a few percent would result in a significant reduction of energy consumption and co2-emissions at the european level. industrial branches with high energy consumption are for example iron and steel making, metal processing and ceramics production. most of the processes are operated at a high temperature level. heat recovery at this high temperature level is essential in terms of efficiency. the most common way for heat recovery is preheating of air or other gas flows by using the energy of the hot waste gas flows. recuperative or regenerative heat exchanger systems, which may be integrated in the burner assemblies, are commonly used for this purpose.  
  
the heat exchangers are manufactured in industrial numbers of pieces using technologies of primary shaping. two different material groups are used. one group is highly alloyed steel grades. these materials can be casted and then joined by welding processes. a great variety in the shape and structure of the surface of the heat exchangers is possible. the metallic recuperators are limited in the application temperatures to about 1050 â°c. the use of alloys with higher application temperature is avoided in industry due to the significant increase of the materials price by an only marginal increase in application temperature. a more recent development are recuperators using the effect of gap flow. these heat exchangers exhibit an increased heat recovery but are also limited in application temperature.   
  
ceramic recuperators used nowadays in industrial burners are tubular. the parts are formed using a slip casting process. this technology allows a moderate structuring of the outer surface of the heat exchangers. due to the deposition conditions the structures at the inner surface of the heat exchanger are less sharp defined. joining of flanges ore other additional parts can only be done in the green unburned state of the ceramic parts. the parts are subsequently transformed into ceramics and infiltrated with liquid silicon. a mechanical treatment of the hard ceramic parts is extremely difficult connected with great expenses and thus reduced to a minimum in industrial production. the ceramic is usually called sisic - silicon infiltrated silicon carbide. it contains some percent of metallic silicon what is limiting the application temperature to about 1350 â°c. the ceramic heat exchangers are used in applications with higher process temperatures or with high thermal loads.   
  
common recuperator lengths are in the order of 0.5 m and hence longer than the thickness of the furnace wall. heat enhancement with structured surfaces is limited due to limitations of the associated ceramic production technologies. given the technological obstructions and the dimensional limitations the level of heat recovery is limited. state of the art recuperative burners show an air preheating and flue gas temperature level after the recuperator in the range of 500 to 700 â°c resulting in heat losses through the flue gas of ca. 25 - 35 % [gas-warme-international 56(2007), 6, pp. 425-428]. regenerative burners (typical nominal power range ca. 200 kw) operate with higher preheating temperatures of the combustion air. due to the larger surface the regeneration temperature reaches 85 - 95 % of the flue gas temperature.   
  
project results:  
  
the following chapter describes the main results and the foreground. the documentation is split and describes the individual result for each partner. the beneficiaries being non-profit organisations and public bodies for secondary or higher education do by nature not focus their activities on commercial aspects. the work is focused on scientific investigation, development of knowledge and improving technologies.   
  
tubaf  
  
introduction  
relative thermo-hydraulic performance optimisation plays an important role in the design of heat exchangers and the choice of heat transfer augmentation technique. in general, heat transfer augmentation is brought about by disturbing the development of thermal boundary layer, which in turn, also disturbs the development of hydro-dynamic boundary layer and hence, increases the pressure drop and the required pumping power.   
  
as far as heat transfer enhancement techniques from the flat surfaces are concerned, there are different alternatives available and their performances are also well documented in the open literature. these techniques include the use of surface roughness, various forms of ribs and turbulators, winglets, swirl generators (like twisted tapes, helical coils, etc.) and inserts, dimples, grooves, to name a few. in the context of the present project, it is proposed to use periodic loop structures, fixed on flat surfaces, as the method for heat transfer enhancement. the numerical study on pressure drop and heat transfer characteristics was made on an arrangement based n flow through parallel plate channels, with one of the walls being fitted with periodic array of wire-loop structures, in order to check the viability of these structures as a potential heat transfer augmentation technique.   
  
possible geometries of wire-loop structures  
the geometric configuration of wire-loop structures can vary in density of loops per unit surface area for example. in principle, the gap between the plates could also be varied. for reducing the costs of the new developed burners, it is necessary to use the already existing burner housings, which cause the gap size. therefore, as far as the geometry of the wire-loop structures is concerned one can vary their arrangement on the plate and their loop density, i.e., the pitch in both the span-wise and the stream-wise directions.   
  
numerical simulations  
repeating module  
a careful look into the possible geometries considered for the present study, reveals that one can always find periodic modules for each of these configurations that repeat themselves in both span-wise and stream-wise directions.   
  
numerical simulations have been carried out for these repeating modules, corresponding to each of the cases listed before by assuming the flow to be periodically fully developed and by imposing appropriate boundary conditions.  
  
boundary conditions  
at the bottom wall (heat transferring surface), impermeable and no-slip boundary condition with specified temperature has been prescribed, whereas, at the upper wall, other than specifying similar boundary conditions for velocities, an insulated boundary condition has imposed. in the stream-wise direction, i.e., at the inlet and the exit of the computational domain, periodicity condition has been implemented. further, the bulk temperature at the inlet has also been prescribed.   
  
numerical details  
as mentioned before, the numerical simulations have been obtained using the commercial cfd code fluent 12.1. since all the simulations have been carried out at higher reynolds number and the flow is expected to be turbulent, a realizible model with enhanced wall function has been used. other than this, the following settings have been used:  
  
1. simple algorithm has been used to deal with the pressure-velocity coupling.  
2. in general, an overall unstructured grid, with structured grid near the solid surfaces, has been used.  
3. second order upwind differencing has been used for all the convective terms.  
4. in general, transient solutions have been obtained, if steady state solution is not found. time marching has been continued till either the steady state solution or the sustained oscillatory solution in time is obtained.  
  
it is worth mentioning that since the solutions have been obtained only for repeating modules by employing the periodicity condition in the stream-wise direction, the flow has been implicitly assumed to be periodically fully developed. it is also evident that such assumption is valid only for constant property flows and hence all the properties of the working fluid have been assumed to be constant. for all the simulations, air has been considered to be the working fluid. for cases - i to iii, properties of cold air at standard atmospheric condition have been used. for case - iv, however, simulations for parallel arrangement have been obtained using the properties of both cold air and hot air at 600oc. the results for the same case (loop density) with in-line arrangement of loops are currently being simulated with properties of hot air and hence, these results are not presented in this report. once obtained, however, these results would be quite useful for comparison at later stage in order to decide upon the orientation of the loops with respect to the flow direction.  
  
results and discussions of numerical simulations  
variations of friction factor and nusselt number  
the variations of friction factor and nusselt number as functions of reynolds number for some cases, a steady state solutions have been obtained but on the other hand, for some other cases no steady state solution could be obtained and hence, computations have been carried out until sustained oscillations in time have been reached. this is due to the vortex shading behind the cylindrical loop structures. it is also evident that for cases of oscillatory solutions in time, one can identify the time-averaged value, the maximum and the minimum values of friction factor and nusselt number. the variations of these quantities as functions of mean reynolds number were identified.  
the results of the multi objective parameter study clearly show that:  
1.average nusselt number increases with the increase in loop density  
2.average nusselt number for staggered arrangement is appears to be higher than the other geometric arrangements  
3.the average nusselt number for opposed diagonal arrangement is higher than that for normal diagonal arrangement  
  
relative enhancement in friction factor and nusselt number  
the friction and heat transfer characteristics, show that as expected, the enhancement in heat transfer is always related to the increased pressure drop. therefore, the enhancement of these values, relative to those for empty parallel plate channel has to be checked. the friction factor and nusselt number for empty channel are calculated according to semi empirical correlations of dittus-boelter, gnielinskie and blasius.  
  
the relative increase in friction factor is higher than that for nusselt number. out of the considered arrangements of loops, it appears that the performance of staggered arrangement is better only at lower reynolds number, although its performance deteriorates quite remarkably with the increase in reynolds number. for diagonal configurations, the opposed diagonal arrangement seems to perform better than the normal diagonal arrangement.  
  
for calculation of the nusselt number and friction factor, the inlet and outlet of the computational domain are selected as the reference surfaces.  
  
conclusions and outlook for numerical simulation  
from the present study, the following conclusions can be drawn:  
1.the average nusselt number, as well as, the average friction factor increase with the increase in loop density.  
2.average nusselt number for staggered arrangement is appears to be higher than the other geometric arrangements. the performance of this arrangement seems to be better than the other geometric configurations only at lower reynolds number but deteriorates sharply with the increase in reynolds number.  
3.for opposed diagonal arrangement, the average nusselt number is higher and the overall performance is better for opposed diagonal arrangement as compared to the normal diagonal arrangement.  
  
in any case it is obvious that the aims of the project are achieved. with the same length of the recuperating element a higher amount of heat can be recovered or the pressure drop can be reduced by transferring the same amount of heat with a shorter recuperating element.  
  
an experimental analysis of metallic and ceramic loop structures  
general information about the test bench  
the experiments were conducted using test bench designed specifically to test these loop structures and to verify the results of the numerical simulation. the test bench measures values such as volumetric flow rate, pressure and temperature. these properties in turn can be used to calculate useful analytical properties such as reynolds number, nusselt number and friction factor. to verify the results of the numerical simulation the same boundary conditions like in the numerical simulation were used. the loop structures are mounted on two water cooled plates opposite to each other. a very thin wall is in the middle to create adiabatic boundary conditions and to guarantee two undisturbed gap channels. a large number of repeating basic geometries is needed in order to avoid border effects on the two insulated (adiabatic) walls on the left and right side.   
  
the overall length of the test bench is 4800 mm. the flow is caused by a side channel blower (maximum volume flow: 450 mâ³/h and 300 mbar pressure drop) and heated with an electrical air heater (16 kw heating power).   
  
for a high similarity in comparison to the numerical simulation it was necessary to avoid vortex structures by the use of a honey comb flow straightener and 3 different metal grids (coarse, medium, fine) for homogenization of the flow. to provide a nearly plug flow at the inlet of the measuring unit a jet nozzle was installed   
  
measured values are temperature using 32 thermocouples, pressure drop on six places and volume flow rate using the hot wire method. the loop surface is 150 x 625 mmâ² on each channel.   
  
the range of reynolds numbers varied between 1000 and 30000 in the measurements. for each different gap size, values were taken at different reynolds numbers in two different ways. the first method is to keep the air heater temperature constant and then vary the blower volumetric flow rate and the second method is to keep the blower volumetric flow rate constant and vary the temperature of the air heater. with the data series from the experiment, properties such as friction factor and nusselt number were calculated. furthermore, these properties could be found at specific lengths of the test bench in the range from 125 mm to 625 mm.  
  
evaluation of the test bench   
for evaluation purpose of the test bench experiments with an empty gap/channel (cross section area: 10.5 mm x 150 mm) are made.  
  
the average nusselt number over reynolds number for measured and expected data based on semiempirical engineering correlations show a very good agreement. in the test bench only a 10 % higher nusselt number were measured due to heat losses and small air leakages. the overall conclusion is that the hot air wind channel test bench is working very well and it is justified to make experiments for evaluation of the numerical results.  
  
experiments with metallic structures  
experiments with metal plates were realized in the next step due to the fact, that metal plates are very accurate in reflecting the geometry from the numerical simulation and ceramic plates were not available at this state of the project.  
geometry 01 with a heat transferring surface: 10.5 mm x 150 mm x 600 mm and a loop density of 3472 loops/mâ² were analyzed in order to validate the numerical simulation. the results for friction factor over reynolds number show a very good agreement between experimental results and numerical calculated data.  
  
ifth  
the main objective of this task is the elaboration of a non fugitive template (structure support) for ceramic conversion. this template is a textile structure obtained by processing sic powder filled polymeric filaments or fibres. this process allows obtaining a continuous material after ceramisation if a sufficient rate of filler is added into the polymer (40 % in volume). but the sic content has to be adapted to the melt spinning process in order to produce filaments with appropriate mechanical properties for textile processing.   
  
first step is to define right raw materials: filler and polymer.   
  
to be compatible with the slurry applied in next step, the chosen filler is sic powder with particular distribution.  
  
as the slurry starts to harden at 140â°c, the polymer has to be chosen with a melting temperature higher than this point. it also has to have a smooth surface in order to get a good coating. ifth has then decided to work with polypropylene, well-known and low cost polymer used in textile industry.  
  
ifth has run different trials in compounding on its spinning pilot plant.  
  
the result of this step is a rod with a non homogenous diameter which was pelletized to transform it in multifilament yarn by melt spinning.  
  
ifth has reached a good proportion of sic (50% in weight) in the rod but the dispersion of sic powder in the polymer matrix was poor. still ifth has demonstrated the spinnability of this blend in monofilament, but the mechanicals properties are inconsistent with textile processing.  
  
in order to obtain a materiel compatible with textile process, ifth has produced multi-filaments from a 25% sic in weight blend on its laboratory melt spinning pilot and from a 10% sic in weight blend on its industrial melt spinning pilot.  
  
the determination of the different component contents in the blend and the study of the morphology by microscopy show a poor dispersion of sic powder in the pp matrix. this dispersion state can be attributed to the low compatibility between the matrix and the filler. moreover, the use of a high content of fillers (25 wt.%) in fibres is not common in textile industry. this induces too low mechanical properties of multifilament yarns for textile processing.  
  
t2200  
the objective of this task is to design a textile structure which could be used as a template for subsequent conversion process as described in annex 1 of the project.  
  
the first step of the work was to define the main specifications of the textile structure in order to select the material and processes.  
  
in order to, ifth has considered specifications from numeric simulation and downstream process. the textile structure has to respect the exchanger drawings from tubaf. these drawings are not common in textile regarding the form, the sequence and the precision.  
the prototypes structures have been produced through two main ways: structures using monofilaments and structures using multi-filaments or staple fibres yarns.  
ifth has experienced several textile technologies in order to produce the right prototypes.  
the textile structures have been made with two type of products: a fugitive template, material bought on market and selected for its residual carbon rate after ceramic conversion and a non-fugitive template, material developed by ifth in t2100.  
  
due to the ceramisation process and the design of heat exchanger, the material which would be used to produce textile structure has to fulfil some specifications:  
-as it will be carbonized in ceramisation process, the polymer should not be too expensive,  
-because of the viscosity of slurry, fibres should have a smooth surface and a large enough diameter in order to get a good coating of fibres by slurry and to avoid air encapsulation between slurry and fibres,  
-as the slurry starts to harden around 140â°c, the filaments should have to melt at a higher temperature,  
-the polymer shrinkage is also important and should be similar to the slurry one to create the same contractions or expansions and then avoid the formation of cracks,  
-the polymer should be hard enough to support the slurry without subsiding.  
  
it has also been defined that the base fabric which would maintain the 3d structure should be in the same material than the loops material but not in the same form (monofilament and multifilament).  
  
ifth has tried different technologies such as trimmings, non-weaving and braiding. these technologies do not allow to fulfil all the specifications in drawing and lightness. the best structures were obtained with weaving and knitting process.  
  
prototyping with weaving technology:  
ifth has carried out several trials with its own equipment or in industrial facility with different materials (fugitive and non-fugitive)  
-pp monofilament, this material was difficult to keep in loops form due to its diameter (1 mm)  
-panox staple fibres yarn, the loops were to fluffy and the base fabric shrinkage during ceramic conversion caused cracks  
-polyester multifilaments, the loops were to fluffy and the slurry did not have a good adhesion on base fabric.  
-non-fugitive multifilaments (developped in t2100), the same problems came up with this material and it was juged by the consortium that not enough residual carbon was brought with this material to continue with.  
  
weaving technology allows to realise textile structures quite in adequation with all the specifications, but the base fabric was too closed to allow a good penetration of the slurry.  
  
ifth has then produced prototypes with weft knitting technology.  
  
prototyping with knitting technology:  
first knitting trials have been carried out with monofilament (diameter 1 mm), this material does not allow a knitting process due to thickness and rigidity of the filament.  
  
the main difficulty with the knitting technology is to fulfil the distribution and alignment of loops. indeed, produce small loops in knitting technology is common, but produce loops with an 8 mm diameter asks specific developments.  
  
ifth has developed a specific drawing on a weft knitting using multi-filaments polyester yarns and solubilised yarn to reach the geometries of exchanger defined by tubaf.  
  
t3000  
ifth has produced samples in geometry 1 and 2 for final prototyping by downstream process.  
erbicol  
  
a new manufacturing process has been developed based on the common schwarzwalder method. starting from a sacrificial template, a green body was obtained by impregnation of a textile in a silicon carbide based slurry. the ceramic intermediate was finally infiltrated with liquid silicon to obtain the final product. following aspects were developed and/or optimized within the project:  
  
template material selection and optimization  
adaptation of the coating path to the new template  
development of a joining process of the green body to an already finished ceramic tube   
optimization of the pyrolysis step  
optimization of the liquid silicon infiltration to the new product  
  
the experimentation performed on the textile template allowed to select a proper material for ceramization. the behavior during ceramic coating (mechanical properties) and the behavior during pyrolysis (thermal properties) were studied to obtain a ceramic intermediate similar or equal to the designed structure.   
  
the first processing path, the impregnation (coating), was adapted to the new conditions. industrially the manufacturing of sic-based products varies depending on the final use and shape of the product. the most common production processes for sic based products are mold processing, extrusion, hot press, cvd and shwarzwalder. however, for the present shape and application, the only applicable process was the coating of the preform through immersion of the template in a ceramic slurry. optimization of the process in order to obtain a replicable quality product with an inclination to scale-up took place. following the ceramic coating, a process was developed in order to join the green ceramic-textile and the already finished tube. a high quality of the joining was obtained, resistant at high temperature. finally, the two thermal treatments, pyrolysis and liquid silicon infiltration, were optimized to fit the new conditions.   
  
as a result, the company was able to manufacture quality structures, whether in form of plate prototypes or as complete recuperative burners tubes, in a replicable manner. a process was developed and optimized that allows fast scale up and cost effective manufacturing of ceramic based loop structures added to a fix substrate like a tube.  
  
another technical result, even if of minor implication, was the adaptation of conventional machining of extra hard materials (diamond tools machining) to the new products. the company was able to precisely machine tubes, plates, foams and any other material used during the project, adding valuable know-how for this manufacturing path.  
  
supsi:  
in combustion environments silicon carbide ceramics are, for their outstanding thermal and mechanical properties, among the best materials . in fact they are commonly employed into high temperature furnaces because, if passive oxidation conditions are met, they withstand operating conditions for long time.   
  
at the beginning of the project three processes were envisaged to fabricate highly structured sic surface elements:  
-chemical vapor deposition (cvd)  
-polymer impregnation and pyrolysis (pip)  
-liquid silicon infiltration (lsi)  
  
chemical vapour deposition produces by far the best material in terms of purity and compactness. it was though immediately abandoned because of their limitations in terms of processing (long times, high costs for thick loops, large furnace availability) and also because these materials in their monolithic forms have rather low thermal shock resistances.   
  
polymer infiltration and pyrolysis was thoroughly studied in the first part of the project: several preceramic polymers were acquired mixed with sic powders to produce slurries for fibres loops coating. slurry viscosity was optimized as well as the coating procedure and ceramization by thermal treatments. this technique showed its limitations in terms of final ceramic compactness and strength. because the polymer upon pyrolysis shrinks and it shrinks on a stable support (i.e. the sisic tube) many cracks occurred. another limitation is given by the non crystalline nature of the sic produced by pyrolysis. this would lead to a lower oxidation resistance.  
  
the main achievement is thus the set up of a production technique ready to be industrialized. in this sense, lsi showed to be the best performer also because of its industrial maturity and also because the commercial sisic tubes are made with a similar technology (proven to be the best performer in a combustion chamber environment) several slurries and coating techniques were thus tested and the optimal composition was chosen in terms of viscosity, green strength, pyrolyzed body microporosity, and final sisic microstructure.  
  
the process was first optimized for planar samples in order to optimize the final product and produce samples for the experimental campaign. the process was further optimized on tubes and finally adopted for the production of functional prototypes and alternative design components.  
  
the final product passed functional tests in a real burner environment and proved to perform significantly better than the standard component.  
  
interesting was also to notice the matching of the experimental results with that of the simulations despite the loop geometry which was slightly different than the nominal one.  
  
noxmat/aichelin: first gas burner application  
  
wp 3000. work and results  
t3100 market study  
the main objective of this work was to collect geometric parameters and thermal properties of existing recuperators and heat exchanger components.   
  
it was difficult to get detailed information, for example for detailed geometry, wall thickness, geometry of the ribs or heat transfer properties such as relative air preheating or pressure drop, about the recuperators.   
  
all burners of the burner manufacturers are assembled modularly. that means that the ports for the media supply (combustion air, cooling air, gas and waste gas) can be staggered at 90 degrees to each other.   
  
there are two different possibilities of flame control for gas burners. the first is to use only one electrode for ignition and ionisation. the second possibility includes one electrode for ignition and a uv sensor for flame control.  
  
recuperative burners are available from several burner manufacturers in different power ranges and fitting lengths. most manufacturers offer a metallic and/ or ceramic design. the geometry of a metallic recuperator is mostly a ribbed geometry. steel recuperators with a plain recuperator or a gap flow recuperator are also available.   
  
the ceramic recuperator burners differ much more in their surface than metallic ones. the ceramic recuperators are generally produced by the process 'schlickerhohlgussverfahren'. because of this process only simple surface structures can be realized. more complicated geometries are more expensive and therefore not economical. the different kinds of surface geometries are burled by lbe, pointed by ws and corrugated by ibs, noxmat and ws. as well as in steel design there are plain ceramic recuperators. (the ceramic material of the recuperators consists of about 88% sic and 12 % free silicon. the ceramic material is characterized by the following properties: consistently mechanical strength up to 1380 â°c, excellent thermal shock resistance, high thermal conductivity of about 28w/mk at 1100â°c, corrosion resistant to aggressive combustion components, no tinder formation, with a density of about 3.1 g/cmâ³ significantly lighter than steel, gastight and no shrinkage of the ceramic during the manufacturing process.)  
  
t3200, t3600, t3700 heat exchanger design and designing of the prototype burner, integration and testing  
a new recuperator with a new heat exchanger geometry had to be integrated in a reference burner. this burner prototype should be based on an existing burner of noxmat k-rhgb series. the main requirements were to define the burner size and to analyse the burner components. it had to be figured out which parts can be reused, modified slightly or developed newly. the next step was to check which geometry is possible for the development of the new heat exchanger element.  
  
the product range of noxmat was analysed by using characteristic numbers of burner dimensions. the main focus laid on the gap-width between the burner tube and the recuperator and accordingly between the recuperator and the radiant tube or insulation of the waste gas chamber. this examination showed that the gap-widths between the tubes were too small for all burner lines. for this reason a burner should be combined with a burner tube of a smaller one. the decision was to combine the burner housing of a k-rhgb 160 burner with a burner tube of a k-rhgb 80 burner. a lot of different concepts of the n ...

# NOTEREFIGA

Project Acronym: NOTEREFIGA

programme & topic: FP7-NMP NMP-2007-4.0-2

Most frequent returning words in objectives:

* ('heat', 60)
* ('fibers', 57)
* ('effect', 45)
* ('samples', 36)
* ('temperature', 35)
* ('thermal', 29)
* ('manikin', 28)
* ('supply', 21)
* ('pcms', 19)
* ('project', 19)
* ('reference', 19)
* ('body', 18)
* ('yarns', 18)
* ('fiber', 18)
* ('textile', 17)
* ('properties', 16)
* ('latent', 15)
* ('garments', 15)
* ('spun', 14)
* ('garment', 14)
* ('range', 13)
* ('lyocell', 13)
* ('cellulose', 13)
* ('fabrics', 12)

executive summary:  
  
the regulation of the body temperature is controlled by the release of heat by blood vessel dilatation or constriction, muscle (shivering) and sweat gland activity. the most comfortable skin temperature is within the range of 28-33â°c. in this comfort zone the human body is unaware of warmth or coolness. outside this range the body feels discomfort. this means that the balance between the rates of heat loss and heat generated must be maintained. this is usually done by putting on or taking off clothes. however, in many situations it would be a significant advantage if the cloths could play an active role in maintaining the body within the thermal comfort zone without taking them off or on that frequently. especially during short term changing conditions this would be of particular relevance. for instance, moving between air conditioned locations in warm climates or going in and out from stores in cold climates. also during short term intermittent physical activity it would be advantageous if the cloths could buffer some of the energy released by the body. for instance, after a short run to the bus stop or departure gate, a cooling effect preventing start of sweating would be of interest.  
  
clothes with built-in thermoregulatory properties may help the body to stay within the comfortable temperature range at different activity levels and ambient conditions. integration of phase change materials (pcms, e.g. hydrocarbon waxes) in clothes is one way of achieving thermoregulatory properties. when the body temperature increases, the pcm melts and absorbs the heat from the body in the form of latent heat (cooling effect). when the temperature drops, the pcm crystallizes and the stored heat is released again (warming effect).  
  
pcms can be integrated into textile fabrics both by means of melt spun bi-component fibers with a sheath/core structure and by using solution spun cellulosic fibers with a dispersed pcm phase. in this way pcm is permanently trapped inside the fibers. both types of fibers have been successfully developed within recently finalized eu funded seventh framework programme (fp7) project noterefiga (nmp2-se-2008-203831). melt spun bi-component fibers (pet, pa) with a latent heat greater than 60 j/g in the temperature range 27-36 â°c and with sufficient strength (tenacity greater than20cn/tex) has been demonstrated in industrial scale production. an industrially feasible and efficient processing concept to produce pcm/polymer alloy with 70% pcm and more in the form of free flowing particles was also demonstrated. suitable bio-based pcms were identified and used. by the application of certain compatibilizers and additives very fine lyocell textile fibers in a range 1.7-2.5 dtex with more than 50% pcm and with properties suitable for further textile processing can be produced. with the developed technology it is possible to get fibers with a latent heat capacity of more than 120 j/g in both pilot and production scale. by the use of cellulose and bio-based pcms, fibers closely approaching 100% in terms of renewable resources are produced.  
  
assessments of thermo physiological properties of the developed fabrics, garments and clothing ensembles has been done using bench scale devices, thermal manikin in climatic chamber and with human subjects in a controlled environment. clear effects of using pcm fibers in garments can be detected in bench scale and with the thermal manikin; the effect is however rather short lasting and depends mainly on the applied pcm surface weight. several test protocols involving human subjects were developed. in the majority of studies using human subjects a statistically proven positive effect could not be confirmed.  
  
dyeing and finishing operations have been successfully applied showing that the pcm fibers developed can be used in standard processes used by the textile industry. lca show similar environmental load as compared to standard textile fibers.  
  
project context and objectives:  
  
the human body is an automatic self thermo-regulated organism. the human body constantly generates co2 and h2o by the metabolism of food and muscle activity. the regulation of the body temperature is controlled by the release of heat by blood vessel dilatation or constriction, muscle (shivering) and sweat gland activity. the most comfortable skin temperature is within the range of 28-33â°c. in this comfort zone the human body is unaware of warmth or coolness. outside this range the human body feels discomfort. this means that the balance between the rates of heat loss and heat generated must be maintained. this is usually done by putting on or taking off clothes. however, in many situations it would be a significant advantage if the cloths could play an active role in maintaining the body within the thermal comfort zone without taking them off or on that frequently.  
  
the objective of the noterefiga project has been to develop novel temperature regulating fibers and innovative textile products for thermal management. the temperature regulating effect is achieved by novel methods of incorporating large amounts of phase changing materials (pcm) in textile fibers. when the body temperature increases, the pcm melts and absorbs the heat from the body in the form of latent heat (cooling effect). then, when the temperature drops, the pcm crystallizes and the stored heat is released again (warming effect). it is assumed that clothes with built-in thermo-regulating properties will provide maintained thermal comfort in difficult thermal environments and physical activity situations. the pcms to be chosen should have a large latent heat (heat of fusion) and melting/solidification temperatures in the range 28-33â°c. during melting the temperature of the pcm stays constant while the heat consumed for melting is stored as latent heat. a well known example of this principle is the use of ice for cooling. a mixture of ice and water will stay at 0â°c as long as there is un-molten ice left.  
  
the noterefiga concept is based on two main ideas. one is based on bi-component melt spinning of fibers with a core/sheath structure confining the pcm to the core. the second is based on a new concept for incorporating pcms in wet spun cellulose fibers based on direct addition of free pcm to a cellulose solution. an important part of the project was devoted to product related research, lead by the small and medium-sized entreprises (sme) in the project. in particular, specific, value-added products were targeted within underwear, sports, leisure, work wear, medical and home textiles as well as in specific technical textiles applications. bio-based raw materials (polymers, pcms) were addressed wherever possible and economical. the project is expected to contribute to the transformation of certain sectors of the european textile and clothing industry from commodities into specific, value-added products securing sustainable growth and employment within the european textile sector.  
  
the main science and technology (s&t) objectives of the project were:  
  
1. to develop novel temperature regulating textile yarns, including bio-based, with significantly improved thermal capability (greater than 60j/g) compared to state-of-the-art (less than 10j/g). this involves material and process development.  
  
2. to check on common finishing operations (mainly dying) for fabrics from the new yarns and propose best practices.  
  
3. to develop protocols for evaluation of the thermal effect and to develop an optimized strategy for the incorporation of the novel temperature regulating fibers in garments.  
  
4. to check on the processability (knitting, weaving) of new yarns and develop new garments with improved thermal comfort to the level of working prototypes.  
  
5. to evaluate possible health and safety issues as well as environmental impact (lca) of new pcm-containing garments.  
  
6. to contribute to the standardization of characterization methods for pcm-fabrics.  
  
project results:  
  
all main project objectives were reached during the stipulated project time. after completed project, industrial scale production of the new fibers is thus expected to commence. for the lyocell type pcm fibers there is already a demand of some 300 tpy identified and the problem is rather a limited available production capacity and a competition with other value added fibers on the same production facility.  
  
noterefiga aims for a much higher market penetration with the pcms than is currently the case. the research activities in the project were aimed for solving longstanding problems with pcms. based on current project results the amount of pcms in the textile can be increased by a factor 5-10 compared to existing commercial pcm-fibers and the development of pcms in finer yarns improve the flexibility of the products. the introduction of pcms in all types of fiber materials (cellulose, polyesters, nylons, polylactide) will increase the potential for use of pcms into any type of textiles. the combination of higher effectiveness and of a broader range of raw materials is a technological breakthrough that will largely broaden the potential market for pcms. together with the research on new and improved textile products, the project also allowed the small and medium-sized entreprises (sme) participants to develop cutting-edge science and technology in the field of compounding, extrusion, clothing design and physiological testing and evaluation.  
  
technical achievements regarding melt spun fibers  
  
optimized pcm/polymer alloys based on paraffin wax and polyolefin viscosity modifiers with regard to thermal efficiency, melt viscosity and cost in order to be able to produce melt spun bi-component fibers with a latent heat greater than 60 j/g in the temperature range 27-36 â°c and with sufficient strength for use in garments and other products (tenacity greater than about 20 cn/tex) has been demonstrated in industrial scale production.  
  
an industrially feasible and efficient processing concept to produce pcm/polymer alloy with 70% pcm and more in the form of free flowing particles was also demonstrated. the pcm/polymer alloys are possible to use with standard melt spinning grades of pla, pet and pa and produce fibers fulfilling the requirements set by the final applications (texturing, dying, finishing, wash ability, health and safety aspects, cost etc.). pp was found not suitable for fiber production due to migration of pcm. the use of nanoclay in pp to reduce migration did not work out despite a proven exfoliation (tem analysis). on the contrary, migration of pcm was increased by addition of pcm. this was tentatively explained by the formation of micro/nano cracks around clay platelets formed during the solid state drawing process of the fibers.  
  
in order to produce fibers with pcm/polymer alloy on standard industrial extrusion equipment it was found necessary to apply certain proprietary precautions. it was also found that the addition of certain proprietary functional additives to the pcm/polymer alloy significantly improved the extrusion performance.  
  
suitable bio-based pcms (functionality and cost) were identified and used in the project. however, a bio-based viscosity modifier for the pcm was not found. this means that about 10-15 % of the fibers will be from non-renewable sources (crude oil) in case of a pla sheath polymer (bio-based sheath polymer).  
  
technical achievements regarding wet spun cellulose fibers  
  
the essential condition to obtain wet spun free pcm containing cellulosic fibers lies in the use of the current lyocell treatment using tertiary amine oxide n-methyl-morpholin-n-oxid to dissolve the cellulose. ensuing from the known technology incorporating microencapsulated pcm, the goal was to integrate free pcms in the cellulosic fiber matrix to achieve higher capacities of heat and finer titers.  
  
substances from the classes of hydrogen waxes such as linear alkyl ethers can be used acting as pcm in the fibers. the main problem to solve thereby is the thermodynamic incompatibility between the hydrophobic pcm and hydrophilic cellulose. so it was essential to find a system of substances consisting of compatibilizers and coupling agents to surmount the incompatibilities between the separate phases. these substances where found in silicic acids to disperse the pcm homogenously and isotropic on the one hand and layered silicates e. g. nanoclays to enclose the pcm and fix them permanently in the cellulosic fiber matrix. the function of layered silicates is to mediate between the hydrophilic cellulose and the hydrophobic pcm because they are hydrophilic at the one side and hydrophobic on the other side. additionally a copolymer is used to interact between the complexes of silicic acids and pcm enclosed between the layers of the nanoclays and fiber matrix. whereas the amount of pcm in the fibers regulates the capacity of heat, the number of carbon atoms in the chain of the hydrocarbons regulates the transition temperature of the pcm. so the producer has the ability to adapt the fibers thermo physiological properties to the requirements of use in a wide range.  
  
by the application of these principles we could produce very fine textile fibers in a range between 1.7 to 2.5 dtex with high contents of more than 50% of pcm and with properties suitable for further textile processing. with the developed technology it is even possible to get fibers with a latent heat capacity of more than 120 j/g in both pilot and production scale. in production scale it was only possible to produce trouble free a fiber fineness of 2.0 dtex, however, these fibers are suitable for further textile processing. by the use of cellulose and bio-based pcms, fibers closely approaching 100% in terms of renewable resources are produced.  
  
sufficient amounts of fibers could be provided for the further textile processing and tests within the project. at the beginning of the processing of staple fibers to yarns problems arose. these were solved by a changed finishing of the fiber.  
  
in spite of the high loading of the cellulose fiber with more than 50 % pcm it could be guaranteed that the phase change material was strongly anchored in the cellulose structure. we haven't found any significant losses of latent heat capacity (heat of fusion) after washing of the textiles made from the highly loaded fibers.  
  
yarn spinning from new lyocell type cellulose staple fibers containing high amounts of pcm  
  
during the development of the yarns different constructions of yarns have been produced in order to reach the highest possible value of heat of fusion. in most cases the pcm modified lyocell fibers from smartfiber with heat of fusion from 45 to 90 j/g have been used (clima fibers). melt spun monofilaments from luxilon were also considered for yarn manufacture (core spun yarn).  
  
the yarns, which are suitable for sports underwear products, have been selected and used to make samples of knitted fabrics for further testing. depending on the results of thermo regulative capacity (heat of fusion) they were selected to be offered to our costumer. so far the results have showed that the new clima fibers are most suitable for the sportswear for which the extreme thermo regulative or thermo isolative properties of the products are not required, particularly at high temperature differences. on the other hand the positive effect of clima fibers to the comfort of the wearer has been proven. it has greater contribution to the improved thermal properties in blends with cellulosic fibers than in blends with woolen or synthetic fibers.  
  
new fibers based on cellulosic fibers with the incorporated pcms are only efficient when used in products which are in direct contact with the skin while wearing. their effect becomes recognizable already when small shares have been added to the product. they can be blended with all kinds of natural and synthetics fibers.  
  
with latest industrial trials we have managed to prove the efficiency of these fibers even in the blends for the core yarns, which are most demanding for spinning - yarns for elastic underwear. the thermo regulative effect would be far less detectable in usual elastic knitting (where the elasticity would be reached by adding nude elastan during the knitting process). in the production the standard spinning equipment and procedure were used at optimized conditions.  
  
so far all the trials have showed the correlation between spinning properties of clima fibers and the content of absolute humidity in the air. this reflects in the static friction fiber â metal and dynamic friction fiber - fiber. with regard to the high share of pcm in the fiber and their distribution within the fiber, different resistance to rubbing and other mechanical as well as temperature influences during the spinning process, ring spinning has been proven as suitable. individual parameters can be changed and different constructions - different kind of yarns can be used and upgraded by using different blends of fibers in the yarn.  
  
the essence of development of the new constructions of the final products derives from the required heat of fusion in the final product and of selected peak melting point with regard to the end-use of the final products. these requirements then further determine the construction of the yarns, of the blends and the type of the used pcms in the fiber.  
  
further development depends on availability of new modified thermo regulative fibers and of requests from market. independently to the requirements of the project partners, marketing activities for the new thermo regulative fibers in special yarns are carried on. these offers are being adjusted to the particular requests of each potential client and the precisely determined target properties of each product. the limit value of the minimal heat of fusion cannot be set generally, but it has to be adjusted to each product individually.  
  
finishing and dying of new fibers  
  
 melt spun bi-component fibers  
  
laboratory dyeing and finishing experiments on knit fabrics made of bi-component filament yarns with high pcm content (pes or pa6 in sheath) were performed. investigation of the dyeing process performance and study of the effects on the latent heat and the dimensional stability of the finished samples in washing were also made.  
  
following the finishing procedures there is no evidence of significant latent heat loss in comparison with the untreated reference. a lower dyeability has been observed in the case of both pet and pa6 yarns with pcm as compared to the corresponding yarns without pcm. the knitted fabric with pcm content displays lighter colors (1â½ or max. 2â½ tones difference) compared to a reference without pcm content. this is expected since the hydrophobic fiber cores will not pick up any dyestuff. the dye will be confined to the pet or pa6 sheath. this effect thus needs to be considered in deciding on the dyeing prescription. the lower pigment pick up of melt spun bi-component fibers with pcm core was also verified in full scale production at fov fabrics.  
  
the presence of pcm in the composition of pet bi-co fiber has no negative influence on the dyeing fastness; good color fastness to washing, acid or alkaline perspiration and very good fastness to dry and wet rubbing was found. high shrinkage of the knitted fabrics during finishing, reduced stretchability and hard handle after finishing remain the main concerns. the hot air setting is not recommended as a method to pre or post-set the bi-co filament yarn pa6 knitted fabrics with pcm content; the alternatives to be taken into consideration are the steam pre-setting or the hot water setting. it is recommended to design the structure of the knits so that the negative effects related to the increase of density, decrease of elasticity and increase of rigidity acquired during wet finishing process is reduced as much as possible. it should be pointed out that these problems probably, to a large extent, can be remediated by a higher temperature in-line annealing during fiber production. they are thus not connected to the presence of pcm, rather to a so far un-optimized melt spinning process in certain aspects.  
  
for pet fabrics an approx. 3% loss in latent heat is recorded after scouring; for the rest of finishing operations there is no evidence of latent heat loss. a somewhat lower color fastness was found in the case of pet samples with pcm as compared to a reference without pcm content.  
  
 wet spun cellulose fibers  
  
laboratory and pilot scale dyeing and finishing experiments on knits made of man-made cellulosic fibers with pcm content, enabling the overall finishing processes influence on physical-mechanical characteristics, thermal properties, dyeability and color fastness properties were performed.  
  
pre-treatments in a single phase or mild alkaline or enzymatic treatments in successive phases are preferred for good results in terms of hydrophilicity, whiteness degree, dyeability and physical-mechanical characteristics of final product.  
dyeing process can be done in a conventional way with good qualitative results in terms of tinctorial yield, evenness and color fastness. causticizing and bio-polish operations should be avoided in the case of blends with cotton due to the high loss of maximum force. in the case of blends with pes, causticizing followed by bio-polish has no negative influence on the maximum force and abrasion resistance. special care should be given to temperature and duration of drying and heat-setting operation, to avoid the loss of latent heat (loss of pcm).  
  
physiological evaluation and thermal characterization of garments with pcm  
  
 sweating thermal cylinder tests  
  
the thermoregulation properties of fabrics developed and produced were evaluated at an early stage in the project by means of the new generation sweating thermal cylinder at tampere university of technology. altogether 7 different samples - out of which four samples included pcm and three samples were references - were considered. the basic properties of the samples were also determined: square mass, thickness, air permeability, thermal insulation and water vapor permeability.  
  
samples containing pcm have clearly cooler feeling when touched by hand than the reference samples without pcm. however, measuring the magnitude and duration of the effect is quite challenging and requires modifications for existing standard test methods used for steady state thermoregulation measurements. also it requires excluding the effect of fabric construction, square mass and thickness which means using samples that have only difference in whether they have pcm or not in their construction. when precooling the samples for the quick dynamic tests it is important that the tested samples have the same temperature before dressing on the cylinder. thicker and denser samples may require longer exposure time in the selected cool temperature than thinner and more air permeable samples.  
  
thin knitted pcm 6, 7 and nopcm8 samples (bi-co filament yarns) have construction, square mass, thickness, air permeability and thermal insulation very much close to each other so the comparison of pcm effect is reliable from that point of view. these samples have the lowest thermal insulation and very high water vapor permeability and very low moisture content in layers after the test. washing did not noticeably affect thermal comfort properties.  
  
nonwoven samples pcmnw1895 and nopcmnw1894 (lyocell with and without pcm) are the thickest samples and they have the highest thermal insulation values meaning that they have a lot of still air bound into their construction. their air permeability is lower than of the thin knitted samples. the reference sample had a little lower square mass, higher thermal insulation and lower air permeability than the pcm sample.  
  
thick knitted samples pcm0127a and nopcm0131a (bi-co filament yarns with and without pcm) are the heaviest samples, the reference sample being the heaviest and having the lowest air permeability. there is not much difference in thermal insulation between the reference and pcm samples.  
  
determination of heat supply shows the differences between pcm and nopcm samples, the pcm samples always having higher heat supply than the reference samples without pcm. when compared to their references the nonwoven samples seem to have the highest, the two-layer thin knitted samples the second highest and the one-layer thin knitted samples the third highest difference in energy per unit area (kj/m2). the duration of the effect varies from 5 to 7 minutes.  
  
determination of outer surface temperature shows also that the pcm samples always have lower outer surface temperature than their references without pcm meaning that they are cooler than their references. the effect varies in magnitude and in duration between different sample constructions and different loads of pcm in the construction. thin knitted samples seem to have the highest outer surface temperatures and the shortest duration for pcm effect. the pcm nonwoven 1895 and the thick knitted pcm 0127 sample have lower outer surface temperature than the thin knits and the effect duration time is higher for pcm knit 0127a. however, higher effects are reached with nonwoven samples in pockets and the highest effects with hydrated inorganic salt packs. the amount of pcm (g/m2) is thus the main factor.  
  
the optimization of pcm has been experimented via using double layers of pcm samples or placing folded test pieces in the pockets of the cylinder garment. as a preliminary result an increase of the effect has been able to be detected in the quick dynamic tests of heat supply and surface temperature. the gain e.g. on using the nonwoven folded samples instead of 30 hydrated inorganic salt packs could be the wearing comfort (flexibility, softness, less weight, possibility for better water vapor permeability or moisture absorption, less super cooling etc.) and perhaps the pcm effect could still be improved and tailored for a particular end use purpose. this optimization need to be studied further.  
  
the effect of sweating on pcm efficiency is a very interesting area to study and it needs further development of the test method. the first determinations clearly showed the existence of pcm effect but also they show that the effect is still rather short tempered.  
  
 thermal manikin test  
  
as part of the noterefiga project thermal manikin tests with 18 different clothing assemblies that incorporated pcm and corresponding placebos were performed. the objectives were to:  
  
1. quantify cooling effects of different garments with different amounts of pcm.  
  
2. compare the effects of pcm on a range of garments.  
  
3. compare garments that incorporate pcm to conventional garments without pcm (references).  
  
a thermal manikin with 16 measurement zones and a constant surface temperature of 34 â± 0.2 â°c was used. the manikin was kept in a stationary upright position. the climatic chamber air temperature (ta) was kept at 34 â°c for all tests. air temperature was measured by three thermistors located 0.5 â± 0.1 m from the manikin's feet, waist and head. the undressed manikin was stabilized in the climatic chamber for 60 minutes in order to ensure stable conditions between the manikin and the environment. heat supply (w/m2) and surface temperature were recorded every 10 seconds for each of the 16 body zones. the climatic chamber air temperature was kept at the same level as the manikin surface temperature (34â°c) in order to obtain isothermal conditions, which should have prevented any heat loss from the manikin to the environment. the clothing samples were kept at 15 â°c during the night before the tests in the climatic chamber. after stable conditions were obtained in the climatic chamber, the samples were fitted to the manikin. the cooling effect of the pcm fabrics and their references was determined by measuring the effect on the heat supplied (w/m2) by the thermal manikin. the heat supply when the manikin was dressed represents the cooling effect of the clothing since the surface temperature of the manikin is unchanged. the clothing included knitted fabrics, pullovers and long johns with different surface weights and pcm loadings and jackets as well as garments with pockets filled with glauber salt (conventional cooling vest). clothing included samples that incorporated pcm and clothing without pcm, representing the reference clothing.  
  
the results show that the duration of the heat supply on the thermal manikin is dependent on the pcm mass and the latent heat of fusion as well as the area covered. the small increase in heating power observed at some of the body segments when the manikin is dressed in the placebo garments is probably due to the fact that all the garments were kept at an ambient temperature of 15 â°c before they were placed on the manikin. the increased heat supply observed is therefore the manikin warming the garment to 34 â°c. some representative findings are summarized below.  
  
knitted sweaters (200 g/m2 fabric with a heat of fusion of 50j/g) from melt spun bi-co yarn (tm=28 and 32â°c) and commercially available pcm packs (tm=24, 28 and 32â°c) integrated in a sweater were compared. the initial cooling effect (first five minutes) of the pcm textile sample with a melting point of 32 â°c was larger than that of the pcm packs. however, the effect of the pcm lasts for a much shorter period of time than the pcm packs. the difference is expected based on the much higher weight of the glauber salt packs. no measurable effect of the pcm sample with melting point at 28 â°c was found, nor on the placebo sample. of the pcm packs, the highest heat supply effect was observed in the packs with a melting point of 24 â°c, followed by the packs with melting points of 28 â°c and 32 â°c. this is expected since the heat flow is proportional to the thermal gradient.  
  
a lyocell based sweater with and without pcm (tm=28â°c) were compared. the maximum values of heat supply on the back and chest segments of the manikin dressed in pcm lyocell were 39 and 30 w/m2, respectively. the heating power lasted for 3-4 minutes. the heating power of the back segment using the reference garment was 6 w/m2, lasting for 10 seconds. no measurable heating power was registered at the chest segment.  
  
pcm lyocell (tm=32â°c) and reference garment 170 g/m2 : the heat supply of all segments of the manikin in contact with the garment rose when it was dressed in pcm lyocell 170 g. the largest increases were observed on the back, chest, lower leg and thigh segments of the manikin. the peak heat supply of the back and chest segments of the manikin was 42 and 38 w/m2 respectively and the effect lasted for 6-7 minutes. no effect of the reference garment could be observed. the peak heat supply values of the lower leg and thigh segments were 32 and 45 w/m2 respectively and the effect lasted for 8-9 minutes. only a small increase in heating power was observed after being dressed in the reference garment. the greater heat supply seen in this garment can be explained by the higher pcm content (45 wt.-%) of the lyocell pcm-fiber which increases the cooling effect on the manikin, resulting in increased heat supply.  
  
pcm lyocell (tm=32â°c) and reference garment 470 g/m2: the heat supply of all segments of the manikin in contact with the garment rose when it was dressed in pcm lyocell 470 g. the peak heat supply values of the upper arm and forearm segments of the manikin were 76 and 56 wâm-2 respectively and the effect lasted for 22-23 minutes. no measurable effect of the reference garment could be observed. the peak heat supply values of the lower leg and thigh segment were 87 and 79 w/m2 respectively and the effect lasted for about 5 minutes. no measurable effect of the reference garment was registered. the even greater heat supply and time effect seen in this garment can be explained by the higher pcm content (45 wt.-%) combined with the greater thickness of the garment. this increased the cooling effect on the manikin, resulting in increased heat supply.  
  
sports jacket with a pcm fiber filled liner (350 g/m2, tm=28â°c) and reference jacket without pcm: both the pcm sports jacket and the reference jacket displayed a cooling effect on all of the dressed segments of the manikin. the peak heat supply values of the pelvis and back segment when dressed in the pcm sport jacket were 37 and 56 w/m2 respectively and the effect lasted for 8-14 minutes. the peak heat supply of the pelvis segment when dressed in the reference jacket was 30-40 w/m2 and the effect lasted for about 4-6 minutes. in all the garments except the sports jacket th ...

# NOTEREFIGA

Project Acronym: NOTEREFIGA

programme & topic: FP7-NMP NMP-2007-4.0-2

Most frequent returning words in objectives:

* ('heat', 60)
* ('fibers', 57)
* ('effect', 45)
* ('samples', 36)
* ('temperature', 35)
* ('thermal', 29)
* ('manikin', 28)
* ('supply', 21)
* ('pcms', 19)
* ('project', 19)
* ('reference', 19)
* ('body', 18)
* ('yarns', 18)
* ('fiber', 18)
* ('textile', 17)
* ('properties', 16)
* ('latent', 15)
* ('garments', 15)
* ('spun', 14)
* ('garment', 14)
* ('range', 13)
* ('lyocell', 13)
* ('cellulose', 13)
* ('fabrics', 12)

executive summary:  
  
the regulation of the body temperature is controlled by the release of heat by blood vessel dilatation or constriction, muscle (shivering) and sweat gland activity. the most comfortable skin temperature is within the range of 28-33â°c. in this comfort zone the human body is unaware of warmth or coolness. outside this range the body feels discomfort. this means that the balance between the rates of heat loss and heat generated must be maintained. this is usually done by putting on or taking off clothes. however, in many situations it would be a significant advantage if the cloths could play an active role in maintaining the body within the thermal comfort zone without taking them off or on that frequently. especially during short term changing conditions this would be of particular relevance. for instance, moving between air conditioned locations in warm climates or going in and out from stores in cold climates. also during short term intermittent physical activity it would be advantageous if the cloths could buffer some of the energy released by the body. for instance, after a short run to the bus stop or departure gate, a cooling effect preventing start of sweating would be of interest.  
  
clothes with built-in thermoregulatory properties may help the body to stay within the comfortable temperature range at different activity levels and ambient conditions. integration of phase change materials (pcms, e.g. hydrocarbon waxes) in clothes is one way of achieving thermoregulatory properties. when the body temperature increases, the pcm melts and absorbs the heat from the body in the form of latent heat (cooling effect). when the temperature drops, the pcm crystallizes and the stored heat is released again (warming effect).  
  
pcms can be integrated into textile fabrics both by means of melt spun bi-component fibers with a sheath/core structure and by using solution spun cellulosic fibers with a dispersed pcm phase. in this way pcm is permanently trapped inside the fibers. both types of fibers have been successfully developed within recently finalized eu funded seventh framework programme (fp7) project noterefiga (nmp2-se-2008-203831). melt spun bi-component fibers (pet, pa) with a latent heat greater than 60 j/g in the temperature range 27-36 â°c and with sufficient strength (tenacity greater than20cn/tex) has been demonstrated in industrial scale production. an industrially feasible and efficient processing concept to produce pcm/polymer alloy with 70% pcm and more in the form of free flowing particles was also demonstrated. suitable bio-based pcms were identified and used. by the application of certain compatibilizers and additives very fine lyocell textile fibers in a range 1.7-2.5 dtex with more than 50% pcm and with properties suitable for further textile processing can be produced. with the developed technology it is possible to get fibers with a latent heat capacity of more than 120 j/g in both pilot and production scale. by the use of cellulose and bio-based pcms, fibers closely approaching 100% in terms of renewable resources are produced.  
  
assessments of thermo physiological properties of the developed fabrics, garments and clothing ensembles has been done using bench scale devices, thermal manikin in climatic chamber and with human subjects in a controlled environment. clear effects of using pcm fibers in garments can be detected in bench scale and with the thermal manikin; the effect is however rather short lasting and depends mainly on the applied pcm surface weight. several test protocols involving human subjects were developed. in the majority of studies using human subjects a statistically proven positive effect could not be confirmed.  
  
dyeing and finishing operations have been successfully applied showing that the pcm fibers developed can be used in standard processes used by the textile industry. lca show similar environmental load as compared to standard textile fibers.  
  
project context and objectives:  
  
the human body is an automatic self thermo-regulated organism. the human body constantly generates co2 and h2o by the metabolism of food and muscle activity. the regulation of the body temperature is controlled by the release of heat by blood vessel dilatation or constriction, muscle (shivering) and sweat gland activity. the most comfortable skin temperature is within the range of 28-33â°c. in this comfort zone the human body is unaware of warmth or coolness. outside this range the human body feels discomfort. this means that the balance between the rates of heat loss and heat generated must be maintained. this is usually done by putting on or taking off clothes. however, in many situations it would be a significant advantage if the cloths could play an active role in maintaining the body within the thermal comfort zone without taking them off or on that frequently.  
  
the objective of the noterefiga project has been to develop novel temperature regulating fibers and innovative textile products for thermal management. the temperature regulating effect is achieved by novel methods of incorporating large amounts of phase changing materials (pcm) in textile fibers. when the body temperature increases, the pcm melts and absorbs the heat from the body in the form of latent heat (cooling effect). then, when the temperature drops, the pcm crystallizes and the stored heat is released again (warming effect). it is assumed that clothes with built-in thermo-regulating properties will provide maintained thermal comfort in difficult thermal environments and physical activity situations. the pcms to be chosen should have a large latent heat (heat of fusion) and melting/solidification temperatures in the range 28-33â°c. during melting the temperature of the pcm stays constant while the heat consumed for melting is stored as latent heat. a well known example of this principle is the use of ice for cooling. a mixture of ice and water will stay at 0â°c as long as there is un-molten ice left.  
  
the noterefiga concept is based on two main ideas. one is based on bi-component melt spinning of fibers with a core/sheath structure confining the pcm to the core. the second is based on a new concept for incorporating pcms in wet spun cellulose fibers based on direct addition of free pcm to a cellulose solution. an important part of the project was devoted to product related research, lead by the small and medium-sized entreprises (sme) in the project. in particular, specific, value-added products were targeted within underwear, sports, leisure, work wear, medical and home textiles as well as in specific technical textiles applications. bio-based raw materials (polymers, pcms) were addressed wherever possible and economical. the project is expected to contribute to the transformation of certain sectors of the european textile and clothing industry from commodities into specific, value-added products securing sustainable growth and employment within the european textile sector.  
  
the main science and technology (s&t) objectives of the project were:  
  
1. to develop novel temperature regulating textile yarns, including bio-based, with significantly improved thermal capability (greater than 60j/g) compared to state-of-the-art (less than 10j/g). this involves material and process development.  
  
2. to check on common finishing operations (mainly dying) for fabrics from the new yarns and propose best practices.  
  
3. to develop protocols for evaluation of the thermal effect and to develop an optimized strategy for the incorporation of the novel temperature regulating fibers in garments.  
  
4. to check on the processability (knitting, weaving) of new yarns and develop new garments with improved thermal comfort to the level of working prototypes.  
  
5. to evaluate possible health and safety issues as well as environmental impact (lca) of new pcm-containing garments.  
  
6. to contribute to the standardization of characterization methods for pcm-fabrics.  
  
project results:  
  
all main project objectives were reached during the stipulated project time. after completed project, industrial scale production of the new fibers is thus expected to commence. for the lyocell type pcm fibers there is already a demand of some 300 tpy identified and the problem is rather a limited available production capacity and a competition with other value added fibers on the same production facility.  
  
noterefiga aims for a much higher market penetration with the pcms than is currently the case. the research activities in the project were aimed for solving longstanding problems with pcms. based on current project results the amount of pcms in the textile can be increased by a factor 5-10 compared to existing commercial pcm-fibers and the development of pcms in finer yarns improve the flexibility of the products. the introduction of pcms in all types of fiber materials (cellulose, polyesters, nylons, polylactide) will increase the potential for use of pcms into any type of textiles. the combination of higher effectiveness and of a broader range of raw materials is a technological breakthrough that will largely broaden the potential market for pcms. together with the research on new and improved textile products, the project also allowed the small and medium-sized entreprises (sme) participants to develop cutting-edge science and technology in the field of compounding, extrusion, clothing design and physiological testing and evaluation.  
  
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optimized pcm/polymer alloys based on paraffin wax and polyolefin viscosity modifiers with regard to thermal efficiency, melt viscosity and cost in order to be able to produce melt spun bi-component fibers with a latent heat greater than 60 j/g in the temperature range 27-36 â°c and with sufficient strength for use in garments and other products (tenacity greater than about 20 cn/tex) has been demonstrated in industrial scale production.  
  
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in spite of the high loading of the cellulose fiber with more than 50 % pcm it could be guaranteed that the phase change material was strongly anchored in the cellulose structure. we haven't found any significant losses of latent heat capacity (heat of fusion) after washing of the textiles made from the highly loaded fibers.  
  
yarn spinning from new lyocell type cellulose staple fibers containing high amounts of pcm  
  
during the development of the yarns different constructions of yarns have been produced in order to reach the highest possible value of heat of fusion. in most cases the pcm modified lyocell fibers from smartfiber with heat of fusion from 45 to 90 j/g have been used (clima fibers). melt spun monofilaments from luxilon were also considered for yarn manufacture (core spun yarn).  
  
the yarns, which are suitable for sports underwear products, have been selected and used to make samples of knitted fabrics for further testing. depending on the results of thermo regulative capacity (heat of fusion) they were selected to be offered to our costumer. so far the results have showed that the new clima fibers are most suitable for the sportswear for which the extreme thermo regulative or thermo isolative properties of the products are not required, particularly at high temperature differences. on the other hand the positive effect of clima fibers to the comfort of the wearer has been proven. it has greater contribution to the improved thermal properties in blends with cellulosic fibers than in blends with woolen or synthetic fibers.  
  
new fibers based on cellulosic fibers with the incorporated pcms are only efficient when used in products which are in direct contact with the skin while wearing. their effect becomes recognizable already when small shares have been added to the product. they can be blended with all kinds of natural and synthetics fibers.  
  
with latest industrial trials we have managed to prove the efficiency of these fibers even in the blends for the core yarns, which are most demanding for spinning - yarns for elastic underwear. the thermo regulative effect would be far less detectable in usual elastic knitting (where the elasticity would be reached by adding nude elastan during the knitting process). in the production the standard spinning equipment and procedure were used at optimized conditions.  
  
so far all the trials have showed the correlation between spinning properties of clima fibers and the content of absolute humidity in the air. this reflects in the static friction fiber â metal and dynamic friction fiber - fiber. with regard to the high share of pcm in the fiber and their distribution within the fiber, different resistance to rubbing and other mechanical as well as temperature influences during the spinning process, ring spinning has been proven as suitable. individual parameters can be changed and different constructions - different kind of yarns can be used and upgraded by using different blends of fibers in the yarn.  
  
the essence of development of the new constructions of the final products derives from the required heat of fusion in the final product and of selected peak melting point with regard to the end-use of the final products. these requirements then further determine the construction of the yarns, of the blends and the type of the used pcms in the fiber.  
  
further development depends on availability of new modified thermo regulative fibers and of requests from market. independently to the requirements of the project partners, marketing activities for the new thermo regulative fibers in special yarns are carried on. these offers are being adjusted to the particular requests of each potential client and the precisely determined target properties of each product. the limit value of the minimal heat of fusion cannot be set generally, but it has to be adjusted to each product individually.  
  
finishing and dying of new fibers  
  
 melt spun bi-component fibers  
  
laboratory dyeing and finishing experiments on knit fabrics made of bi-component filament yarns with high pcm content (pes or pa6 in sheath) were performed. investigation of the dyeing process performance and study of the effects on the latent heat and the dimensional stability of the finished samples in washing were also made.  
  
following the finishing procedures there is no evidence of significant latent heat loss in comparison with the untreated reference. a lower dyeability has been observed in the case of both pet and pa6 yarns with pcm as compared to the corresponding yarns without pcm. the knitted fabric with pcm content displays lighter colors (1â½ or max. 2â½ tones difference) compared to a reference without pcm content. this is expected since the hydrophobic fiber cores will not pick up any dyestuff. the dye will be confined to the pet or pa6 sheath. this effect thus needs to be considered in deciding on the dyeing prescription. the lower pigment pick up of melt spun bi-component fibers with pcm core was also verified in full scale production at fov fabrics.  
  
the presence of pcm in the composition of pet bi-co fiber has no negative influence on the dyeing fastness; good color fastness to washing, acid or alkaline perspiration and very good fastness to dry and wet rubbing was found. high shrinkage of the knitted fabrics during finishing, reduced stretchability and hard handle after finishing remain the main concerns. the hot air setting is not recommended as a method to pre or post-set the bi-co filament yarn pa6 knitted fabrics with pcm content; the alternatives to be taken into consideration are the steam pre-setting or the hot water setting. it is recommended to design the structure of the knits so that the negative effects related to the increase of density, decrease of elasticity and increase of rigidity acquired during wet finishing process is reduced as much as possible. it should be pointed out that these problems probably, to a large extent, can be remediated by a higher temperature in-line annealing during fiber production. they are thus not connected to the presence of pcm, rather to a so far un-optimized melt spinning process in certain aspects.  
  
for pet fabrics an approx. 3% loss in latent heat is recorded after scouring; for the rest of finishing operations there is no evidence of latent heat loss. a somewhat lower color fastness was found in the case of pet samples with pcm as compared to a reference without pcm content.  
  
 wet spun cellulose fibers  
  
laboratory and pilot scale dyeing and finishing experiments on knits made of man-made cellulosic fibers with pcm content, enabling the overall finishing processes influence on physical-mechanical characteristics, thermal properties, dyeability and color fastness properties were performed.  
  
pre-treatments in a single phase or mild alkaline or enzymatic treatments in successive phases are preferred for good results in terms of hydrophilicity, whiteness degree, dyeability and physical-mechanical characteristics of final product.  
dyeing process can be done in a conventional way with good qualitative results in terms of tinctorial yield, evenness and color fastness. causticizing and bio-polish operations should be avoided in the case of blends with cotton due to the high loss of maximum force. in the case of blends with pes, causticizing followed by bio-polish has no negative influence on the maximum force and abrasion resistance. special care should be given to temperature and duration of drying and heat-setting operation, to avoid the loss of latent heat (loss of pcm).  
  
physiological evaluation and thermal characterization of garments with pcm  
  
 sweating thermal cylinder tests  
  
the thermoregulation properties of fabrics developed and produced were evaluated at an early stage in the project by means of the new generation sweating thermal cylinder at tampere university of technology. altogether 7 different samples - out of which four samples included pcm and three samples were references - were considered. the basic properties of the samples were also determined: square mass, thickness, air permeability, thermal insulation and water vapor permeability.  
  
samples containing pcm have clearly cooler feeling when touched by hand than the reference samples without pcm. however, measuring the magnitude and duration of the effect is quite challenging and requires modifications for existing standard test methods used for steady state thermoregulation measurements. also it requires excluding the effect of fabric construction, square mass and thickness which means using samples that have only difference in whether they have pcm or not in their construction. when precooling the samples for the quick dynamic tests it is important that the tested samples have the same temperature before dressing on the cylinder. thicker and denser samples may require longer exposure time in the selected cool temperature than thinner and more air permeable samples.  
  
thin knitted pcm 6, 7 and nopcm8 samples (bi-co filament yarns) have construction, square mass, thickness, air permeability and thermal insulation very much close to each other so the comparison of pcm effect is reliable from that point of view. these samples have the lowest thermal insulation and very high water vapor permeability and very low moisture content in layers after the test. washing did not noticeably affect thermal comfort properties.  
  
nonwoven samples pcmnw1895 and nopcmnw1894 (lyocell with and without pcm) are the thickest samples and they have the highest thermal insulation values meaning that they have a lot of still air bound into their construction. their air permeability is lower than of the thin knitted samples. the reference sample had a little lower square mass, higher thermal insulation and lower air permeability than the pcm sample.  
  
thick knitted samples pcm0127a and nopcm0131a (bi-co filament yarns with and without pcm) are the heaviest samples, the reference sample being the heaviest and having the lowest air permeability. there is not much difference in thermal insulation between the reference and pcm samples.  
  
determination of heat supply shows the differences between pcm and nopcm samples, the pcm samples always having higher heat supply than the reference samples without pcm. when compared to their references the nonwoven samples seem to have the highest, the two-layer thin knitted samples the second highest and the one-layer thin knitted samples the third highest difference in energy per unit area (kj/m2). the duration of the effect varies from 5 to 7 minutes.  
  
determination of outer surface temperature shows also that the pcm samples always have lower outer surface temperature than their references without pcm meaning that they are cooler than their references. the effect varies in magnitude and in duration between different sample constructions and different loads of pcm in the construction. thin knitted samples seem to have the highest outer surface temperatures and the shortest duration for pcm effect. the pcm nonwoven 1895 and the thick knitted pcm 0127 sample have lower outer surface temperature than the thin knits and the effect duration time is higher for pcm knit 0127a. however, higher effects are reached with nonwoven samples in pockets and the highest effects with hydrated inorganic salt packs. the amount of pcm (g/m2) is thus the main factor.  
  
the optimization of pcm has been experimented via using double layers of pcm samples or placing folded test pieces in the pockets of the cylinder garment. as a preliminary result an increase of the effect has been able to be detected in the quick dynamic tests of heat supply and surface temperature. the gain e.g. on using the nonwoven folded samples instead of 30 hydrated inorganic salt packs could be the wearing comfort (flexibility, softness, less weight, possibility for better water vapor permeability or moisture absorption, less super cooling etc.) and perhaps the pcm effect could still be improved and tailored for a particular end use purpose. this optimization need to be studied further.  
  
the effect of sweating on pcm efficiency is a very interesting area to study and it needs further development of the test method. the first determinations clearly showed the existence of pcm effect but also they show that the effect is still rather short tempered.  
  
 thermal manikin test  
  
as part of the noterefiga project thermal manikin tests with 18 different clothing assemblies that incorporated pcm and corresponding placebos were performed. the objectives were to:  
  
1. quantify cooling effects of different garments with different amounts of pcm.  
  
2. compare the effects of pcm on a range of garments.  
  
3. compare garments that incorporate pcm to conventional garments without pcm (references).  
  
a thermal manikin with 16 measurement zones and a constant surface temperature of 34 â± 0.2 â°c was used. the manikin was kept in a stationary upright position. the climatic chamber air temperature (ta) was kept at 34 â°c for all tests. air temperature was measured by three thermistors located 0.5 â± 0.1 m from the manikin's feet, waist and head. the undressed manikin was stabilized in the climatic chamber for 60 minutes in order to ensure stable conditions between the manikin and the environment. heat supply (w/m2) and surface temperature were recorded every 10 seconds for each of the 16 body zones. the climatic chamber air temperature was kept at the same level as the manikin surface temperature (34â°c) in order to obtain isothermal conditions, which should have prevented any heat loss from the manikin to the environment. the clothing samples were kept at 15 â°c during the night before the tests in the climatic chamber. after stable conditions were obtained in the climatic chamber, the samples were fitted to the manikin. the cooling effect of the pcm fabrics and their references was determined by measuring the effect on the heat supplied (w/m2) by the thermal manikin. the heat supply when the manikin was dressed represents the cooling effect of the clothing since the surface temperature of the manikin is unchanged. the clothing included knitted fabrics, pullovers and long johns with different surface weights and pcm loadings and jackets as well as garments with pockets filled with glauber salt (conventional cooling vest). clothing included samples that incorporated pcm and clothing without pcm, representing the reference clothing.  
  
the results show that the duration of the heat supply on the thermal manikin is dependent on the pcm mass and the latent heat of fusion as well as the area covered. the small increase in heating power observed at some of the body segments when the manikin is dressed in the placebo garments is probably due to the fact that all the garments were kept at an ambient temperature of 15 â°c before they were placed on the manikin. the increased heat supply observed is therefore the manikin warming the garment to 34 â°c. some representative findings are summarized below.  
  
knitted sweaters (200 g/m2 fabric with a heat of fusion of 50j/g) from melt spun bi-co yarn (tm=28 and 32â°c) and commercially available pcm packs (tm=24, 28 and 32â°c) integrated in a sweater were compared. the initial cooling effect (first five minutes) of the pcm textile sample with a melting point of 32 â°c was larger than that of the pcm packs. however, the effect of the pcm lasts for a much shorter period of time than the pcm packs. the difference is expected based on the much higher weight of the glauber salt packs. no measurable effect of the pcm sample with melting point at 28 â°c was found, nor on the placebo sample. of the pcm packs, the highest heat supply effect was observed in the packs with a melting point of 24 â°c, followed by the packs with melting points of 28 â°c and 32 â°c. this is expected since the heat flow is proportional to the thermal gradient.  
  
a lyocell based sweater with and without pcm (tm=28â°c) were compared. the maximum values of heat supply on the back and chest segments of the manikin dressed in pcm lyocell were 39 and 30 w/m2, respectively. the heating power lasted for 3-4 minutes. the heating power of the back segment using the reference garment was 6 w/m2, lasting for 10 seconds. no measurable heating power was registered at the chest segment.  
  
pcm lyocell (tm=32â°c) and reference garment 170 g/m2 : the heat supply of all segments of the manikin in contact with the garment rose when it was dressed in pcm lyocell 170 g. the largest increases were observed on the back, chest, lower leg and thigh segments of the manikin. the peak heat supply of the back and chest segments of the manikin was 42 and 38 w/m2 respectively and the effect lasted for 6-7 minutes. no effect of the reference garment could be observed. the peak heat supply values of the lower leg and thigh segments were 32 and 45 w/m2 respectively and the effect lasted for 8-9 minutes. only a small increase in heating power was observed after being dressed in the reference garment. the greater heat supply seen in this garment can be explained by the higher pcm content (45 wt.-%) of the lyocell pcm-fiber which increases the cooling effect on the manikin, resulting in increased heat supply.  
  
pcm lyocell (tm=32â°c) and reference garment 470 g/m2: the heat supply of all segments of the manikin in contact with the garment rose when it was dressed in pcm lyocell 470 g. the peak heat supply values of the upper arm and forearm segments of the manikin were 76 and 56 wâm-2 respectively and the effect lasted for 22-23 minutes. no measurable effect of the reference garment could be observed. the peak heat supply values of the lower leg and thigh segment were 87 and 79 w/m2 respectively and the effect lasted for about 5 minutes. no measurable effect of the reference garment was registered. the even greater heat supply and time effect seen in this garment can be explained by the higher pcm content (45 wt.-%) combined with the greater thickness of the garment. this increased the cooling effect on the manikin, resulting in increased heat supply.  
  
sports jacket with a pcm fiber filled liner (350 g/m2, tm=28â°c) and reference jacket without pcm: both the pcm sports jacket and the reference jacket displayed a cooling effect on all of the dressed segments of the manikin. the peak heat supply values of the pelvis and back segment when dressed in the pcm sport jacket were 37 and 56 w/m2 respectively and the effect lasted for 8-14 minutes. the peak heat supply of the pelvis segment when dressed in the reference jacket was 30-40 w/m2 and the effect lasted for about 4-6 minutes. in all the garments except the sports jacket th ...

# SERVIVE

Project Acronym: SERVIVE

programme & topic: FP7-NMP NMP-2007-3.1-2

Most frequent returning words in objectives:

* ('customization', 39)
* ('servive', 35)
* ('production', 32)
* ('mass', 28)
* ('project', 27)
* ('information', 27)
* ('product', 26)
* ('options', 25)
* ('matteo', 24)
* ('dosso', 24)
* ('order', 22)
* ('business', 19)
* ('micro', 19)
* ('customer', 19)
* ('model', 18)
* ('products', 16)
* ('customers', 16)
* ('retailers', 16)
* ('company', 16)
* ('offers', 14)
* ('data', 12)
* ('challenges', 12)
* ('factory', 12)
* ('clothing', 11)

executive summary:   
  
 servive is an eu funded project within the 7th framework and intends to implement mass customisation throughout europe on a wide and large scale. it is resident in the fashion and apparel industry and its main goals are:   
- the enlargement of the assortment of customisable items currently on offer,  
- the drastic enhancement of all co-design aspects (functionality and fun) and  
- the development and testing of a new production model based on decentralized networked sme cells.   
  
 many research projects lack the transfer from scientific research" to "making money in business". after three years, eu funded project servive now has to prove its promise to build a platform that connects mass customization suppliers and vendors within the apparel industry. logging into the servive community (http://community.servive.eu) offers a world of sites like amazon and facebook combined: shop mass customized apparel from different suppliers, have your own profile and show your configured products to friends. besides the fact that you are able to shop mass customized products instead of mass produced ones, you are also able to build up a virtual twin of yourself, have a look at the clothes you desire on your avatar and get advice from experts on your looks.   
  
 project context and objectives:   
  
 the overall project objective was to scale-up the amount of mass customization production systems as well as the amount of consumers using the phenomenon as possibility to shop. to serve both parties of the market, we developed a platform that perfectly connected both sides and fulfilled requirements of customers as well as suppliers. this platform makes it possible to spread the mass customization phenomenon out to wider europe, using a professional system that is able to incorporate every new mass customizer very easily. this is especially of interest for small or medium sized enterprises as they can use the servive services and platform to reach a high number of potential customers. on the other side consumers are able to easily find and compare mass customized offerings and benefit from the servive services.   
  
 however, the aforementioned business framework can only be considered successful if:   
- all target groups (consumers) are motivated to choose from and have easy access to the mc services and mc products offered in the foreseen business framework.  
- all other value chain mc actors (retailers, manufacturers, material providers, service providers) are confronted with clear and strong gains from participating in the foreseen business framework.  
- the community benefits are significant and can be quantified.   
  
 the goal of our business model is to provide trust, choice and service to both consumers and suppliers. while developing a realistic business model and exploitation plan, we therefore had two directions to follow:   
1. what are the needs and requirements of a supplier?  
2. what are the needs and requirements of a consumer?  
  
 target group   
  
 the target group has been derived by examining the mass customization landscape of the apparel industry. in order to do that, a matrix has been created, which shows the amount of companies already on the market, according to the type of apparel and customization options.   
  
 taking these insights into consideration, the three most promising market niches targeted by the servive consortium are:   
- women's business wear  
- knitwear (male/female)  
- sportswear   
  
 women's business wear offers a great opportunity, because it is still a white spot in the market. however, the vast experience from the men's segment regarding processes, such as sourcing, manufacturing and sales, can be transferred to the women's segment. this leaves the consortium with more scope for developing a service experience suited for women's special while shopping.   
  
 knitwear on the other hand can be produced locally and on demand in micro factories. this provides the opportunity to offer an optimal degree of variety without jeopardizing profitability. moreover, knitwear appeals to a very wide range of customers from almost every milieu. therefore, customized knitwear can be used to disseminate the idea of mass customization to a wider public. last but not least, a local production offers the opportunity to employ workpeople locally.   
  
 regarding sportswear, a competitive advantage can be achieved by making full use of the customization range (from, fit and function). whereas the concept of mass customization has an inherent focus on costs in most definitions, the servive consortium believes that differentiation is the key to create a sustainable competitive advantage.   
  
 co-design framework   
  
 another focus of the project was to create a co-design framework. but for this idea to work, success factors have to be identified first. crucial for the success of the servive portal are the factors service, choice and trust, which are important to both consumers and suppliers. retailers, on the other hand, benefit from minimizing risks and costs, which occur because of acting as an intermediary between the two previous mentioned parties. however, previously retailers used about 80% of the buying budget to purchase garments from wholesalers, while saving some proportions of the budget for contingencies. in turn, the biggest share of clothing sold can be regarded as standard offers, which are less profitable. in order to encourage customers to purchase higher priced items, which do not belong to standard clothing, two considerations have to be kept in mind: on the one hand the store has to generate a healthy profit, but on the other hand this implies taking risks. this risk has to be compensated by mire commercial propositions.   
  
 production framework   
  
 another goal of the servive project is the introduction of a new approach of producing garments. to produce customized garments at near mass production efficiency, certain requirements must be met and the production processes have to be adjusted. mass customization describes a strategy to offer customized products, while producing them at the efficiency of mass production. this approach implies for garments a make-to-order approach, meaning that the production can only begin after all specifications have been made. those specifications include customer related preferences and characteristics, such as body proportions. therefore, it is of advantage for companies to produce in close proximity to the customer instead of mass producing in asia. customers, who order a piece of clothing, do not want to wait two month till their desired product arrives. to exploit the potential of mass customization in the clothing industry, new production models have been developed, focusing on the coordination of configurable networks. within these networks there are micro factories, which act as independent entities. since micro factories are a completely new concept, the whole process chain has to be designed. for this the company unicatum has been chosen as a pilot, focusing on automatic knitting.   
  
 the reason for developing the ipc is to offer every actor in the network the opportunity to generate pattern blocks in an easy way. this includes personal body measurements, which are integrated within the customized pattern blocks. the main features offered by this service are:   
  
- achievement of good fit  
- compatibility with different garment styles  
- adaption to the target group  
- data format compatibility  
- compatibility with modern software.   
  
 project results:   
 1 the servive challenge   
  
 as projects - and especially research projects - are always faced with challenges, this next chapter deals with these ones we had to consider. but we rather saw these challenges as opportunities to improve the achievements deduced from the aforementioned project objectives.   
  
 to boost the mass customization phenomenon within the fashion industry leads to challenges in two main domains: a market one with decisions that mainly affect the customer as well as a more company one that affects internal processes. of course both parts are strongly interconnected. we split the following chapter into five parts that deal with   
- the strategic decision of the "right" business model,  
- the development of an appropriate solution space,  
- the therefore arising product configuration paradigm,  
- connected with recommendation and help services for the customer,  
- closing with the challenges arising by a micro factory production model.   
  
 1.1 sustainable business model   
  
 besides the choice of target groups and before deciding on product ranges, we had to think of the best distribution model regarding our ideas. along with that we had to consider that most distribution models, which will be listed below, are linked to a specific business model.   
  
- manufacturer/supplier centric model  
- retailer/seller centric model  
- consumer centric model  
- "all inclusive" portal model  
  
the above mentioned business models lead to the following conclusions:  
- the above mentioned models offer lots of variations to implement them. for example, home sales or "personal experts" can be used as a distribution channel.  
- depending on the product type, specific issues of each distribution model have to be taken into consideration  
- the most suitable model for the servive project appears to be the "all inclusive" model, because products are manufactured, which enter all areas of the distribution chain. the integrated solution will offer the most benefit, because on this basis new value added services and other innovations can be developed.  
- companies already active in the industry can be individually supported by using some servive results.   
  
 1.2 choice of customization options   
  
 mass customization as strategy can be split into two dimensions: an internal one, concerning the complexity in fulfillment, sales and distribution and an external one, concerning the opportunity to profit from market heterogeneity. the internal dimension relates to the degree of variety, namely the solution space, which defines the number of options offered. the external dimension varies from partial customization, which involves the possibility to customize form, fit or function, to complete customization, which enables the customer to customize all three options.   
  
 as it is servive's goal to create a template for new business entrants, which want to adopt to the mass customization strategy, the development of our business model is a crucial one also with regard to quantity and quality of offered custtomization options. the function of the blueprint is to act as guidance for adopting, implementing and accelerating business for new entrants in the field of mass customization in the fashion industry.   
  
 1.3 product configuration paradigms   
  
 the different pilots of the servive project, namely unicatum, matteo dosso and team colors, offered different backgrounds and, therefore, needed different approaches to be implemented into the servive project. hence, each pilot is suited well in order to focus on different aspects of the goals of the project. whereas unicatum was mainly focused on implementing new production strategies, such as micro factories, matteo dosso's focus was to develop an appropriate solution space, which is described above. in the case of team colors, however, the challenge of scaling up smes to the field of mass customization is documented. this will be presented below.   
  
 1.3.1 matteo dosso pilot   
  
 matteo dosso gmbh & co. kg is responsible for the target group ladies' wear, made-to-measure clothing and corporate fashion and its core business includes:   
  
- made-to-measure ladies' wear on mass customization principles   
 the assortment of matteo dosso offers a fashionable variety, which takes individual preferences of customers into account. pieces of clothing available within the assortment are: skirts, trousers, jackets, waistcoats, overcoats, blouses and tops. the distribution channel of matteo dosso includes a range of different retailers, ranging from high-quality specialist's shops over large retailers to retailers with special alignments. as can be seen in the range of different retailers, the company does not sell directly to consumers.   
  
- corporate fashion on made-to-order and mix and match principles   
 to cover this range of products, matteo dosso offers individual business fashion collections, which aim at expressing the company philosophy of the customer. in this category two options are available to the customer: designing an own collection or choosing from a mix and match collection. this service is offered both to companies directly or to retailers.   
  
 the pieces of clothing available from matteo dosso are offered either using the matteo dosso brand or a private label. however, the company takes care of all necessary steps within the supply chain itself. this includes the creation of the design, procurement of materials, cutting and product and quality management. in addition, the company owns all rights regarding the designs and patterns.   
 during the pilot of the servive project a 3-piece-suit from the matteo dosso catalogue has been selected for demonstration purposes. this piece of clothing consists of a jacket, trousers and a skirt.   
  
 taking the example chosen above, matteo dosso offers customization options stated below:   
- more than 70 customization options to choose from for each product.  
this includes buttons, pockets, linings, stitching, embroidery etc. regarding those options, there usually is a wide range of different colors and styles available.  
- for fabrics, there is a base collection, consisting of about 300 high-quality fabrics from renowned weavers. however, customers can also choose fabrics, which are not in the base collection but are still offered by the weavers cooperating with matteo dosso. this leaves room for thousands of different fabrics.  
- measurement adjustments can be applied to the widest possible range to achieve a perfect fit.  
- the list of customization options is updated continuously by matteo dosso each season.  
  
in the following some of the customization options are described in a more detailed way, to offer insights on the company's product catalogue.   
  
 matteo dosso offers its products using the partnership with customax, in order to reach the market both with products of their own or a private label. retailers use a product configurator on the customax portal to configure a product with the help of the product catalogue of matteo dosso. this configurator offers real-time information on the availability of fabrics and prices for fabrics are shown in real-time as well depending on the region and client group. if a product is finally customized, matteo dosso receives the orders via xml-files and the information is processed automatically for stock- and cad-systems. besides this way of receiving orders, it is also possible for the company to accept orders sent by fax, by email or files sent by a 3d body scanner via order software.   
  
 besides the customization options related to the design of the product, there is also a wide range of options available regarding the fit of a product, which is mandatory for made-to-measure products. for the exemplary 3-piece-suit the measurements required will also be listed in the annex. however, in order to gain all necessary information, a test piece is offered, on the basis of which all changes are carried out. even if a 3d- scanner is used, a test piece is still necessary to take individual fit preferences of the customer into consideration. this difference between the body of the customer and the test piece is then indicated on the master pattern. taken the measurements of the test piece and the posture assessment of the 3d scanner, small alterations can be made to include the fit preferences of the customer, however, the changes should not exceed a value of 0.1 to guarantee a decent fit.   
  
 whereas in cases of customizable products within standard e-environments, database structures and pricing information are straightforward, the structure within the servive project cannot be realized in the same way. this project works as a single-piece multi-enterprise structure and is implanted into the customax platform. this highlights the need for a more complex workflow management. in a multi-enterprise mass customization environment, the special requirements in terms of multi-enterprise databases, pricing tables and multi-product catalogues become apparent and issues related to these topics are presented.   
  
 whereas in a standardized e-environment product information entities are generated using a range of direct attributes according to a predefined structure, in the servive project, the attributes are created dynamically. this implies that the resulting price for a customized product is strictly dependent on the unique set of attributes.   
  
 for instance, the direct attributes offered by the company matteo dosso and the pricelists, which are generated using a complex set of variables, can be seen below:   
- country/region  
- client classification  
- model selected  
- materials used  
- style and options selected  
- site  
- special services  
  
taking the attributes above into consideration, the pricing rules of matteo dosso can be regarded as complex. this complexity is labeled "the product configuration paradigm" by customax and is characterized by:  
- single-piece workflow management in a multi-enterprise environment  
- a single product can be sold in different countries, to different clients at different prices  
- depending on the country and the client different options and measurements are available for a product.  
  
 another feature offered by the customax platform, which further increases the complexity of the project, is the option for clients to dynamically configure the product catalogues of the multi-enterprise environment. for example, a btob customer of matteo dosso is harrods of london. for this specific customer, matteo dosso can activate a certain price list for this customer, but at the same time, the customer has the opportunity to activate or deactivate customization options in the product catalogue for consumers. furthermore, harrods could fix sales prices by configuring the pricing module regardless of the customization options chosen by the consumer.   
  
 1.3.2 the team colors pilot   
  
 team colors is another pilot of the servive project, which was established in 2002. run as a family business serving the clothing needs of the elderly, it refocused its target group to women's sportswear. similar to the other servive pilots, they offer bespoke clothing for both individual customers as well as customer groups, such as corporate clients or teams. within this segment, outfits for netball and football, including shirts, shorts and netball dresses etc., are the core products. due to the growth and focus on unique styles, the company realized an increased need for flexibility, which led to the switch to local manufacturing from out-sourcing abroad. in doing so, the company also replaced its catalogue with e-commerce, using a transactional website. this website already offered services, which helped customers to co-design products with a configurator. this opportunity addressed a keener sense of style and, moreover, increased the consumer satisfaction of the predominantly female target group, which was confronted with rather functional than fashionable products from other competitors.   
  
 the assistance of the servive project focused on scaling up mass customization for this sme. therefore, different aspects, which were influenced by the project will be described, highlighting management, workspace and new technologies.   
  
 the main impact of the project on the management of team colors was related to the response of the management team to an "agile design" ethos. hence, the impact focused on design and manufacture. this led to decreased stock because of a printing-to-order approach, which is able to change the appearance of basic materials completely. another impact on management can be seen in the increased staff, which amounts to 20 employees by now. in the course of this growth, new ways of acquiring new employees were chosen, such as the knowledge transfer partnership scheme. however, at first no suitable candidates could be found, that offered training in cad/cam fashion design and methodological knowledge to implement the vertigraph system at the same time. however, other graduates were found, whose knowledge and web-based skills complemented the use of cad. with this development the company is well prepared for the future, by having the opportunity to implement new trends, such as mobile applications, for example.   
  
 in order to adjust the workspace to the growth of the company, the servive project also made changes to the layout. team coulors is located in a sme business complex in hertfordshire. typically for this kind of buildings, it offers a charmingly characterful atmosphere but lack the comfort associated with modern enterprises. since team colors occupies the ground and first floor premises of the building, it is clearly hard to efficiently use the workspace. this is emphasized by the lack of good lifts and narrow stairs, which link the floors with each other. naturally, the company is well aware of its own priorities and needs, but in order to evaluate changes and to consider benefits of moving areas, the management consultant dr. claire hussey was asked for advice. after gaining insights to different issues, such as work flow models, data methods used or personnel needs, layout reports, timescales and a process map was delivered and changes to technologies or the enhancement of space were proposed. team colors gradually adopted suggestions, which mainly added flexibility to the infrastructure and smoothened workflows by altering areas.   
  
 1.4 customer support functions   
  
 additional challenges regarding the structure of servive project occur when integrating different services and features into the whole network. since the servive portal will act as a repository or a wide range of european brands, companies can benefit from support regarding different issues. for example, research has shown that crucial components for an online shopping experience are entertainment features. even though the online environment offers lots of technical features for fashion companies, only few are able to present themselves in an appropriate way to appeal to customers. instead a strong focus is often put on technical features and a poor web design is offered to the consumer, which usually deters them. falsely, this approach addresses the utilitarian needs of the customer instead of offering a hedonistic shopping experience.   
  
 to counter those false assumptions, challenges related to innovative interface design, co-design, style advice and social networking are identified and possible solutions are presented.   
  
 another common problem is related to the overwhelming variety of customization options available, which can cause confusion and inertia among consumers. this problem is related to as mass confusion.   
  
 moreover, consumers are more likely to take longer time in order to come to a decision while shopping for clothing. this can be observed by the shopping behaviour of customers, when they visit additional stores and ask shop personnel for advice. online shopping offers the benefit of making different offers comparable with little effort. while some of this shopping behavior can be considered as normal, both in online and offline shopping, there are other sources of frustration.   
  
 this leads to the conclusion that key information has to be offered at an early stage to the consumers in order to prevent frustration. this key information could be, for example, color availability or price. while a help function is usually available to customers, it deals with issues related to navigation and processes. in the process of buying apparel, however, the help required is personalized and context specific. therefore, successful style advice can be the required element, which turns overwhelming into satisfactory choice.   
  
 1.5 micro factory approach   
  
 additional challenges occur because of the chosen production form of micro factories, especially concerning required data and corresponding data format. a special feature of decentralized production networks is the use of micro factories. this enables the member of the servive project to share their production capacity. in this case, an order can be transferred to a micro factory, but detailed information regarding sizes, pattern etc. from the ordering party is necessary. to ensure constant quality, each micro factory has to be able to produce a prototype of each type of product.   
  
 the type of information required is depending on the type of micro factory within the network. however, the way in which the data is exchanged may vary, namely depending on different scenarios or the connection to pos, but the required data itself must be precise. the degree of co-design options or the degree of the customization does not have an influence on the information exchange. the product customization solely takes place using the product configurator. for this procedure the mc garment distributor/developer is responsible and predefines any options. the micro factory starts working at the point of time, when the order acquisition has been finished.   
  
 for each micro factory data related to customers, orders, production and products has to be provided, in order to guarantee efficient production. in the special case of global orders micro factory related factors, such as skills, have no influence on the required data either. however, to match appropriate micro factories with each order, the type of production data and its content depends on the process scenario of micro factories as well as its organisation and productions capabilities.   
  
 2 addressing the challenge   
  
 in order to cope with the challenges described in above, the modules in the following list are integrated into the servive project.   
  
 servive principal modules (pm)  
- virtual try-on services (vto service)  
- virtual try-on web application (vto web app)  
- personalisation server (pserver)  
- recommendation engine (recomeng)  
- micro-factory network coordinator (mfnc)   
- intelligent pattern configurator (ipc)   
  
 servive integration platforms (ip)   
- servive portal incl. style community (spo)  
- servive transaction platform (spl)  
  
 as most of these modules are described in the highlighted achievements in the next chapter or the overall results in the chapter thereafter, we decided to enlarge on the elementary challenges within this chapter.   
  
 2.1 body measurements   
  
 the major challenge of determining the body shapes of the target group was solved by using various successive methods.   
  
 although the challenges of choosing the important measurements and the way to measure them was been discussed before, in this structure, a precise process is established, which covers the challenges by defining clusters and measurements.   
  
 2.2 work and data flow micro factory   
  
 regarding the challenges occurring while establishing the complex micro factory production network, a knowledge base for production knowledge has been created. this includes working steps, production organisation and work plans. this is of importance especially in the field of mass customization because a large amount of experience about production with its variations is required. this is supported by the two different ways of producing garments used in the project, namely sewn and knitted garments. in either case garment production has to be regarded as production of lot sizes of one. this implies that each order needs an individual production plan.   
  
 due to the nature of the mass customization approach, the costs and complexity of production organization are influenced by different factors, which can cause additional costs and production time:   
- size of factory/number of workers  
- skill of personnel  
- technical equipment  
- production method- sewing, knitting   
  
 2.3 knowledge architecture   
 in order to cope with this challenge, an integrated knowledge architecture has been developed. since information from various sources is input for the servive network, it has to be managed efficiently. sources of information are, for example, human morphology or the manufacturing domain. taking the style advice service as an example the chain of information till a suggestion can be made will be:   
  
 body type, style, human style color, trend, occasion -garment suggestion   
  
 therefore, different rules have to be applied to take the needed information from different domains:   
  
- style advice rules are stored in the pserver in the form of stereotypes. whereas the left side of the rule shown above consists of customer attributes the right side can be seen as the output of the rule. the pserver will act as a personalization tool and stores user models and stereotypes. hence, the pserver can produce stereotypes using data mining algorithms and assigns users to appropriate stereotypes.   
- attribute rules regarding the acquisition of the required data are specified in the servive owl ontologies.   
  
 information from different domain sources is integrated into the servive ontology. this structure of the architecture is supported by integrated knowledge repositories.   
  
 the structure of the flow of information is as follows. the repository of basic information, which is needed to define the customization options is located in the domain of the garment developers. accordingly, they define, which information is needed regarding the customization options and provide retailers with this knowledge. with this knowledge, retailers are able to market the garments. in turn, the preferences of the customers are gathered by using the product configuration process.   
  
 depending on the different scenarios studied within the servive project, the content and workflow of information differs. this is related to the relationship between the different actors in the network, namely garment developers, manufacturers and retailers. therefore, the precision and the volume of required information may vary. in the following brief descriptions of the different scenarios are offered:   
  
 scenario 1 - team colors and unicatum: current scenario   
 team colors and unicatum occupy nearly all types of roles within the servive network, namely developers, suppliers, retailers and manufacturers. however, it has to be noted, that unicatum filed for bankruptcy, but to prove the feasibility of the model its tasks were taken by ifth and ntu. still for this report, the pilot concept to produce knitwear etc. will be referred to as unicatum. in the case of etui-dresses, all relevant information used are defined, generated and used in-house. therefore, there is no need for order specific production information. only information regarding the style variant, workmanship and body measurements are needed in order to start production. four production patterns are generated based on the body measurements and the personnel is able to manufacture the rest of the garment according to the customer's preferences. in order to minimize production and organization costs within the micro factory, an automated generation of customized work plans is chosen.   
  
 scenario 2 - matteo dosso: current scenario   
 matteo dosso takes the role of a garment developer and supplier within the sni platform, while production is located in factories of partner companies. however, the company offers detailed information regarding permitted customization options to retailers. the needed information on customization preferences of customers is gathered by retailers, using try-on pieces. there, design options are noted and pattern alterations are created using adjustments of the try-on piece. once this information is forwarded to matteo dosso, work patterns are created, which are sent to a factory chosen by the company. furthermore, factories are chosen, which work for matteo dosso for a longer period, which facilitates quick processing and reduces the complexity of the information required to produce the customized product.   
  
 scenario 3 - unicatum: future scenario   
 in this scenario unicatum wants to offer its products using the sni platform in addition to its other roles as garments developer, supplier and producer. in order to offer those products on the sni platform, detailed descriptions of the customization options has to be provided. in turn, retailers forward the customization preferences of customers to the sni. the ...

# ESPRIT

Project Acronym: ESPRIT

programme & topic: FP7-NMP NMP-2007-2.4-1

Most frequent returning words in objectives:

* ('heating', 51)
* ('materials', 38)
* ('matrix', 33)
* ('task', 33)
* ('project', 26)
* ('properties', 25)
* ('temperature', 23)
* ('reinforcement', 20)
* ('injection', 20)
* ('processing', 20)
* ('polymer', 19)
* ('induction', 19)
* ('microwave', 19)
* ('fibres', 16)
* ('fibre', 16)
* ('process', 16)
* ('polymers', 16)
* ('yarn', 16)
* ('sheets', 15)
* ('system', 14)
* ('shrinkage', 14)
* ('pellets', 13)
* ('processes', 13)
* ('partners', 12)

executive summary:  
   
 self reinforced polymer composites (srp) are thermoplastic composites which have a matrix and reinforcement of the same polymer family. the advantages are lighter, stiffer, more impact resistant and recyclable composites. the current state of the art at the beginning of the project was pp-based flat sheets which, although having some excellent properties, are limited in their application because of the moulding limitations of flat sheets. the esprit project (fp7 contract number 214355) was created to develop srps beyond the existing flat-sheet formats and make flowing materials for complex 3d shapes along with novel selective heating by means of electromagnetic energy.  
   
 the partners successfully made the intermediate materials required. pellets were made from commingled fibres which were then pultruded into rods and then chopped. they were also made by melt impregnation of matrix into reinforcement and again chopped into pellets. sheet materials were made by powder impregnation of the matrix into various textiles or fibre reinforcements and also by extruding the srp pellets into sheets. to facilitate electromagnetic heating additives such as iron powder or carbon nano tubes (cnt) were successfully compounded to an excellent distribution quality.  
   
 these intermediate materials were heated and formed. induction energy was used to heat sheets and subsequently form them. microwave energy was also used to heat susceptor-laden sheets to a point where they could be moulded. pellets were injection moulded into various complex shapes proving that, with carefully controlled parameters, flowing srp is a reality.  
   
 the esprit project achieved the set objectives of an srp with 30% weight reduction (htpet/lpet) which can be flow-moulded. controlled selective heating was also achieved, by induction and microwave methods, and the efficiency of conductive heating was improved by a dual-channel heating system with a unique energy battery. as with many new materials it is difficult to bring the costs down to a competitive level but a very promising example of an srp is the htpet/lpet combination which can sell at 7 eur/kg compared to an equivalent pbt with glass fibre at 4 eur/kg but when the weight reduction is taken into account (replacing glass with pet) the difference becomes quite narrow and, of course, the srpet has good recycling credentials, a growing requirement for many end users.  
   
 an array of case study parts was made to demonstrate the new technologies, ranging from automotive parts, to fans, sportswear and hand- tool parts. some parts are relatively simple shapes but with, for example, exceptional impact properties, others have thin walls and ribs and demonstrate stiff, lightweight parts. the injection moulded parts were achieved with standard machines albeit with close attention paid to the process parameters.  
   
 the post-project development and collaboration has continued into further research proposals thrown up by the esprit work and into commercial applications such as luggage, sports goods, medical apparel and consumer goods already being pursued by various partners in collaboration and individually.   
   
 project context and objectives:  
   
 background  
   
 the european plastics industry, worth an overall eur 200 billion per annum, saw a decline in the number of plastic injection moulders of 9% from 2000 to 2006. slowing economic growth, oem price pressure, rising raw material costs and the relocation of manufacturing to asia, have all combined to put pressure on injection moulders, demonstrating the need for new knowledge-based materials and process techniques to maintain the european leadership in this sector. the materials developed within this project aim to offer that competitive advantage to european moulders whilst also bringing environmental impact advantages.  
   
 srp composites have been present in the market since the 1990's but only in the form of textiles or sheets which creates severe limitations on applications possible. netcomposites initiated the esprit project, gathered the european experts and created a vehicle for the development of new materials and processes to make the next generation of flowing srp materials. by developing these flowing srp materials and the processes to use them esprit has opened more opportunities for designers and manufacturers and more opportunities to reduce the volume of plastics used.   
   
 objectives  
   
 the aim of the esprit project was to develop the next generation of lightweight, self-reinforced polymer composites together with the energy-efficient manufacturing processes needed to produce components from this family of materials and as a consequence reduce the amount of plastic used to make components. the targets were set at a 30% reduction in materials used and therefore a commensurate 30% reduction in weight.   
   
 the concept for the esprit project was therefore to develop flowing versions of self-reinforced plastics from commodity polymers â polyolefins, polyamides and polyesters â and key to this was the development of techniques that will allow the selective melting of the polymer matrix without causing adverse effects on the polymer reinforcement fibre. this necessitated the development of energy-efficient microwave and induction-heating techniques to allow selective melting of the matrix polymer. high performance, commodity polymers were used to develop self-reinforced plastics with significantly enhanced properties over existing plastic and, for the first time, the ability to be compression and injection moulded into complex shapes.  
   
 in broad terms the aims were to develop flowing self-reinforced polymer composites with a strength or stiffness at least 3 times higher than the parent polymer, develop cost-effective heating and moulding processes for flowing self-reinforced plastics and to carry out technical and commercial evaluation of the developed materials and process by manufacturing and testing 3 case study parts.  
   
 the overarching scientific methodology was the development techniques to allow the polymer matrix to melt and flow without causing shrinkage, melting or loss of properties in the polymer reinforcement, given that the matrix and reinforcement are two forms of the same base polymer. two approaches were taken to this challenge:  
   
 - differential melt temperatures  
 - selective heating  
   
 these materials would then be trialled by using compression and injection moulding technologies, first of all on a small scale to characterise the various combinations, additives and techniques and then on a larger scale to produce case studies to demonstrate the advancements.  
   
 partners  
   
 the esprit partners were selected to give a mix of expertise in specialist research areas, for knowledge of materials or processes and for industrial activity in related areas. the partners are listed below:  
   
 - netcomposites ltd  
 - comfil aps  
 - fibroline france sarl  
 - institut fuer verbundwerkstoffe (ivw) gmbh  
 - regloplas ag  
 - fricke und mallah microwave technology gmbh (f and m)  
 - aimplas â instituto tecnologico del plastico  
 - promolding bv  
 - ticona  
 - avk ev + european alliance for thermoplastic composites  
 - polisilk sa  
 - pemu muanyagipari zartkoruen mukodo reszvenytarsasag  
   
 project results:  
   
 description of main s & t results/foregrounds   
   
 the work carried out was divided into logical work packages in order to plan and manage the activities and therefore the results of the project are presented in the same sub-divisions.  
   
 wp 1 definition of materials, processes and applications  
 - task 1.1 - definition of materials, processes and applications  
 - task 1.2 - details of heating techniques and processing routes to be used in the project  
   
 these two subjects are in many ways co-dependent and so were reported in tandem through the project. these tasks relate to the early laying of foundations in order to assess all the possible options and to start the project in a sensible, considered direction. the knowledge generated through these tasks was a comprehensive flow chart of the processing routes, leading to an understanding of requirements leading in turn to a list of all possible polymers which was then narrowed down to some key candidates based on a thorough analysis of properties. the matrix and fibre materials were naturally reviewed together as they can feature in the same srp and need to be considered as a unit.   
   
 after considering the alternatives the esprit consortium agreed the following would be chosen as the materials to be pursued:   
   
 - commodity polymers: polypropylene (pp), tm 140â°c - 175â°c, service temperature ~ 80â°c, very low cost  
 - technical polymers: nylons (pa, including semi aromatic pas) large range of tm (180â°c - 283â°c), good service temperature (90â°c - 160â°c), large range of grades giving a range of properties and prices  
 - polyesters (pet) high tm (255â°c), high service temperature if matrix is crystalline, low cost  
 - speciality polymers: none were selected at this point as the raw material properties were deemed are so far unsuitable for srp aspirations.   
   
 additives  
   
 additives were considered at this point as well, the amount, type and quantity of additive used affects not only the accuracy and success of the heating method but also, potentially, the properties of the srp itself. great care must therefore be taken in selecting and testing the additives.   
   
 heating systems  
   
 having selected the appropriate polymers the heating systems were considered. these were broadly laid out in the dow but more detailed consideration was given now to the microwave, induction, infrared and thermal transfer methods.  
   
 processing  
   
 out of the possible processing routes various stages were considered and partners agreed basic requirements for the pre-processing stages of pultrusion, commingling, powder impregnation and speciality chopping. in addition the processing stages were considered and the concepts of investigation set out: injection moulding and compression moulding  
   
 task 1.3 broad outline specifications for case study components  
   
 from task 1.1 and 1.2 decisions were made about materials and process which in turn allowed the planning of possible demonstrators. a table of desired properties was created based on the expected scope of case studies possible. three typical mouldings were selected as being a complex injection moulding, a large high aspect compression moulding and large high aspect injection moulding. as expected, later in the project the aims moved slightly as the materials and processes were developed. not every category was explicitly covered but many more demonstrators from varied applications were actually made  
   
   
 wp 2 modification and heating of matrix materials  
   
 task 2.1: chemical modification to reduce matrix melt temperature  
   
 reducing the melt temperature of the matrix phase of an srp is desirable in order to increase the 'processing window' of the composite, which is the difference between the melt temperature of the matrix and the point at which the reinforcement fibres begin to degrade (lose their mechanical properties). in this task aimplas carried out modifications on the 3 main selected polymer groups from wp1:  
   
 - polyesters  
 - polyolefins  
 - polyamide  
   
 task 2.2: compounding of matrix polymer systems with heating promoters  
   
 in order for the later processing tasks to have raw materials to work on it was necessary for aimplas to investigate the compounding of various susceptors into the matrix polymers. the following work showed a progression from dispersion with many agglomerates, to an excellent homogeneous result. the compounding parameters were closely monitored and recorded and were then passed later in the project to partners for up-scaling in larger quantities.  
   
 task 2.3: development and evaluation of microwave, induction, infrared and conduction heating   
   
 microwave heating  
   
 basic tests were carried out to ascertain the effectiveness of the additives and the compounding process. multimode (aimplas) and monomode (netcomposites) microwave (mw) systems were used and it was clear that the monomode was much more efficient but more difficult to control, so attention was paid later to novel control and implementation systems. cnts were shown to be 10 to 20 times more efficient than carbon black and it was also decided that 2.45 ghz gave a more efficient heating effect than 5.8ghz (both systems were supplied for trials) and would be the system of choice.  
   
 induction heating  
   
 tests by ivw on the aimplas-compounded polymers showed that iron showed the best induction heating behaviour and that carbonous semiconductor particles didn't work as induction susceptors. the effect of frequency, concentration and particle size were studied and several solutions were applied to improve the heating homogeneity. the outcomes were passed onto the later work packages.  
   
 infrared heating  
   
 both dark radiator and short-wave radiators were used for testing the effectiveness of infrared (ir) heating. it was found by aimplas that additives had little or no effect and therefore selective heating was not possible. the heating was also effective only on the surface. it was agreed that ir heating would not be taken forward into the rest of the project.  
   
 task 2.4: preparation of matrix materials for subsequent process stages  
   
 working with other partners aimplas provided compounded samples which were analysed for heating efficiency in mw and induction processes with a feedback loop to optimise particle size, percentage of additive and dispersion. they were then able to supply various compounds to partners.   
   
 having established the compounding methods and materials aimplas also used software to first of all create an accurate simulation of their own processing and then to upscale the parameters to larger machines at pemu. various parameters were analysed: residence time, dissipated energy, specific energy, melting energy, torque and mixing efficiency. this was successful and is described later in the report.  
   
 wp 3 development of reinforcement fibre systems  
   
 task 3.1 modification of fibre polymers to increase temperature stability  
   
 a number of activities were pursued in order to improve the temperature stability and properties of the reinforcement fibres:  
   
 manufacture and measurement of raw materials  
   
 from wp1 fibres (ht pet, ht pa46, ht pa66, ppa, pp, lcp, lpbt, pa6 and pct) were selected and further tested, spinning them if required. the overall goals were to:  
   
 - improve initial modulus,  
 - improve overall modulus,   
 -reduce shrinkage,   
 - improve tenacity and   
 - reduce filament diameter.   
   
 dsc and dmta analysis was carried out to ascertain melt temperatures and mechanical properties and the following materials were chosen for the project:   
 - pp â htpp polisilk   
 - pet â commercial grades (comfil supply)  
 - pa â commercial grades (solvay amodel ppa)  
 - lcp - commercial grades (vectran hs)   
   
 heat setting and drawing  
   
 one of the potential problems with the reinforcement element of an srp is shrinkage of the fibre during processing and fibre shrinkage can start before the melt temperature of the fibre is reached. it is therefore preferable to modify the reinforcement fibre to be as stable as possible at as higher temperature as possible  
   
 the principle of heat setting is to take a yarn which has been manufactured and drawn and to expose it to a temperature above its shrink point whilst it is under tension and then to cool it back down to ambient. this has the effect of allowing the molecules to relax and they become more resistant to shrinking when they are subsequently re-heated. what was discovered is that heat setting reduces the shrinkage effect but the penalty is reduced mechanical properties. as expected, subsequent processing has a further negative effect on mechanical properties.   
   
 irradiating  
   
 irradiation of fibres by gamma radiation causes ionisation in the polymer molecules which promotes cross-linking between them, which, in theory, improves temperature resistance. trials were carried out with pp fibres, as a standard fibre and as a fibre which has been extruded with a sartomer (trimethylolpropane trimethacrylate) additive. this additive is recommended as promoting successful irradiation.  
   
 a selection of polymers (18 samples) were compounded with the additive, drawn and then sent for irradiation trials by ionisos.   
   
 additives  
   
 it was concluded that cnt reduces shrinkage of the pp yarn considerably but at the penalty of decreased tenacity of the yarn, as the more cnt content, less tenacity is achieved. cnt presence also allows a higher draw ratio than with standard pp, this partly compensates the loss of tenacity mentioned above. cnt slightly increases the modulus of the yarns at low contents. even though cnts have proven to reduce shrinkage considerably these reductions were not enough to consider cnts as a solution to the shrinkage problems of reinforcement yarn. at the same time modulus is decreased and there is no other advantage associated to its use.  
   
 task 3.2 performance evaluation of modified reinforcement polymers  
   
 different partners and suppliers use different units and properties when describing the strength/stiffness of yarns and so a method of standardising measurements for the project was needed so a standard method of obtaining comparable yarn modulus values was made, using a simple spreadsheet. it is important to know at what temperature the onset of shrinkage occurs in each of the reinforcement fibres and it is important to know âhowâ the fibres shrink, gradually over a range of temperatures or suddenly at one temperature. a hot-stage microscope was used for some initial investigation by netcomposites and they recorded a video of fibre shrinking over time as the temperature increased. this was later dropped as a test but it was recognized, that it is a useful bench mark for comparative work and that it provides data on the real onset of shrinkage.  
   
 task 3.3 spinning and drawing of high tenacity filaments and tapes  
   
 polymers selected form the results of tasks 3.1 and 3.2 were melt-spun into fibres and drawn to achieve a high orientation and tenacity. the aim of task 3.3 was to increase the mechanical performance of yarns made of pp and pet. the task was expanded slightly as there are different ways to alter the mechanical properties in order to produce suitable yarn for the benefit of the aims of the project: increase yarn tenacity, increase modulus and reduce shrinkage. the chosen routes were: carbon nanotubes, nanoclays, nucleating agents, taslan textured yarn to increase interface with matrix, an adstif high modulus pp, extrusion of pp yarn with sartomer + cross linking  
   
 carbon nanotubes  
   
 the conclusions were that cnt decreases the tenacity of the yarn, as more cnt content, less tenacity achieved. cnt presence allows a higher draw ratio than with standard pp, where the maximum draw ratio is around 8. in pp+cnt draw ratios up to 9 were achieved, this partly compensates for the loss of tenacity mentioned above. cnt slightly increases the modulus of the yarns at low contents and reduces the shrinkage of the pp yarn considerably.   
   
 nanoclays  
   
 in srp's the matrix plays a very significant part in the overall properties of the composite and in this task the aim was to improve the properties of the matrix polymer by the addition of nanoclays so that the benefits of the low melting point could be exploited to give a wider processing window. aimplas produced a pp + nanoclay masterbtach that was processed into yarns by polisilk. the masterbatch gave no problems when processed into yarns but the mechanical strength was significantly reduced by the presence of nanoclays.  
   
 nucleating agents  
   
 nucleating agents change the crystalisation behaviour of polymers. several nucleating agents were considered and finally two versions were trialled. they were extruded by polisilk but unfortunately gave no increase in mechanical performance  
   
 pp taslan yarn  
   
 in order to improve yarn/matrix interface from the fibroline powder impregnation process it was thought that it could be possible to alter the physical shape of the filaments. instead of having flat filaments waves and loops were introduced to the filaments thereby improving interfacial bond and the mechanical properties of the srp composite and also reducing the shrinkage of the fibres at high temperatures as they are firmly held within the matrix. once again the advantages gained in terms of fibre/matrix adhesion were negated by the loss of mechanical properties.  
   
 adstif pp  
   
 this grade chosen has a high modulus but elongation at break was somewhat lower (17%) compared to standard pp which is 20-22%. the biggest difference found was shrinkage in hot air at 130 c for 1 min. which was only 2,4% compared to 9-10% in normal pp, modulus was 3,52 gpa. because of the poor results in mechanical strength, adstif was abandoned as a reinforcement yarn option, but continued as a matrix option.  
   
 extrusion of pp yarn with sartomer  
   
 the addition of a masterbatch sartomer and further cross-linking via ionisation could help increase the thermal and mechanical properties of certain polymers by transforming a linear network of polymer chains into a three-dimensional network by a direct linking of carbon atoms.   
   
 task 3.4 commingling/bi-component extrusion of reinforcement and matrix polymers  
   
 commingling was shown to be successful as a method of combining matrix and reinforcement for subsequent pultrusion (it can also be used for weaving fabrics). this process uses a system of feed and pull-off rollers to pass yarns through a controlled air-blast, resulting in intimately mixed multi-filament fibres. a very large number of samples were created by comfil covering pet, pp, pa, pbt and hdpe. an innovation introduced for the esprit project was to include a small percentage of black 'tracer' fibre (5%) into the reinforcement yarn. this is the same yarn but pigmented. this allowed easy visual examination of the srp composite later in the process flow.  
   
 wp 4 development of flow compounds  
   
 task 4.1: processing of lft pellets for injection and compression moulding  
   
 two routes were pursued to achieve pellets:  
   
 pultrusion from commingled yarns  
   
 the line built by comfil for the project performed a series of operations sequentially. it fed commingled yarns under controlled tension to a preheating station before the die which heats and melts the matrix. this makes a consolidate rods which is cooled down and chopped into pellets. this line was highly successful and included some innovative features such as a two-stage drying and heating process, with an inert-gas shielding system and chopper to make pellets which could handle the normally difficult task of chopping non-brittle fibres. it made medium-sized batches of pellets for partners throughout the project and proved flexible in its ability to take various commingled yarns, at different ratios and with different base fibres. conclusions were drawn for each type of combinations fibres/ matrix based on the characteristics of the rods.  
   
 melt impregnation of reinforcement yarns with molten matrix  
   
 the conclusion of this task showed that as a first approach it was good to use model material, htpet-pp, to validate the feasibility of lft. then, numerous trials of polymer combinations led to improvements of the both impregnation processes. the two companies involved in this work have produced many batches of material for the other partners with numerous variations based on the type of pellet, amount of fibres, fibre preparation and different additives in the matrix. for some of these srp, the mechanical properties are very interesting and choices were focused on the following the most interesting combinations:  
   
 task 4.2: development of sheet semi-finished materials for compression moulding  
   
 the route to achieve the semi-finished sheets was the fibroline powder-impregnation process, which had not previously been used to manufacture thermoplastic composites or srp materials. the first work done was to characterise the possible matrix and reinforcement options using the same 3 basic polymer families agreed in wp1.   
   
 task 4.3: development of microwave, induction, infrared and conduction heating methods  
   
 microwave  
   
 the microwave machine was capable of heating sheet materials with a high degree of consistency over the surface. original thermal images show the heating effect without the reciprocating plunger and demonstrate the peaks in heating caused by the standing microwave. after developments the thermal images show a sheet using the manipulated mw with good heating homogeneity and the graphs which show the temperature profile across the sheet ate several points. for any given profile the temperature variation is 10 to 20oc which is very promising and can be improved with further refinement of the control system and additional programmability. the profiles show difference to each other because the sheet is cooling as it emerges from the machine. an alternative system supplied by f and m used a chamber with multiple antennas which was trialled and did not work in its initial format. there were some issues with mw escaping the system which were not resolved in the lifetime of the project but which will be worked on after the project finishes.  
   
 induction  
   
 trials were carried out on the materials generated in wp 2 and 3 using new induction heating equipment.  
 it was proven that with the correct additives and control system induction heating could heat a polymer, hold it at temperature and then allow cooling. this shows very promising results for later applications.  
   
 conduction heating  
   
 conduction heating refers to using a more conventional hot water or oil system to heat tools direct, in order to control heat or to provide a complete cycle of heating and cooling. esprit partner regloplas developed a system particularly suited to tightly controlled temperature, quicker cycle times that use the energy-intensive process of heating and cooling, an unusual requirement from the use of srp materials.   
   
 a dual circuit system was developed which continuously runs hot and cold channels from 2 separate units, one heating, one chilling. later in the project the 'energy battery concept' was introduced which allows the storage of hot or cold energy for later re-use when the cycle goes full circle, shown on right. several iterations were trialled as there are particular problems in controlling hot and cold systems in a very dynamic way. concurrently an advanced control system was developed to provide active, real-time feedback control based on the can-bus system. the system has been successful enough to generate immediate customer interest  
   
 task 4.4: physical analysis of semi-finished materials pre- and post-heating  
   
 the main objective in this task was to evaluate the performance of the materials, processes and outputs in order to see what effect additives, repeated heating and cooling, pressures and so on would have on flowing srp materials in the form of pellets and sheets.  
   
 wp 5 net-shape injection and compression moulding processes  
   
 task 5.1: injection moulding using conduction preheating of lft pellets  
   
 this task involved taking the new compounds and the knowledge gained about materials and their processing limits and investigating the possibilities of injection moulding flowing srp. the particular challenges are to overcome uncontrolled heat generated by shear in the barrel, nozzle, sprue and tool and to maintain the required processing window.  
   
 three streams of development were identified and multitude of tests and evaluations were carried out with injection moulding machines and their elements. both the hardware, as well as the process parameters were examined.  
   
 a series of test specimens (tensile and impact bars, plates) were produced and mechanically tested. this task concluded, after a review of all possible processing variants suitable to be used for the manufacturing of srp. these were further refined during the manufacture of case studies and some final recommendations made for a 'best practice' document  
   
 task 5.2: compression moulding using induction, ir & microwave heating of semi-finished sheet   
   
 compression moulding using induction  
   
 for the compression moulding trials with induction heating, fibroline hdpe/pp sheets as well as celstran pp/pet tapes were used. the manufactured plates with the dimension of 120 x 120 mmâ² had a thickness of 2 mm. these sheets were then tested and characterised (fibre integrity, impact).  
   
 the optimal results were then trialled practically, using a moving induction coil to heat a sheet and to form a shoe cap, as used in protective shoes. in contrast to a convection oven the heating time of semi-finished sheets could be reduced by 40 %. additionally, the induction heating process indicated limits in terms of component size and efficiency: a lower temperature at the edges in comparison to the centre of the semi-finished sheets due to thermal losses to the environment was observed. the application of induction assisted particle heating was revealed to be a feasible method for the preheating of self-reinforced materials in thermoforming processes. the method was able to decrease the necessary preheating time in comparison to a convection oven. furthermore, the impact results and the microscopy observation lead to the conclusion that the induction heating does not damage the fibrous reinforcement and decrease the material impact properties.   
   
 microwave heating of semi-finished sheets   
   
 the conclusions for the microwave heating of semi-finished sheets case-study were:   
 - the woven fabric material displays much more homogenous heating due to greatly improved matrix distribution compare to the random reinforced spr;  
 - all the pre-consolidated sheets still having small problems with cnt agglomerations;   
 - increasing the matrix of a random reinforced material to increase the microwave sensibility doesn't give the effect that was expected (quicker heating);   
 - the manipulated mw significantly improves the homogeneity of heating across the material;  
 - the microwave technique is fast and efficient with polypropylene based sheet material heated to moulding temperature in only a few seconds using a 1kw magnetron;  
 - microwave technology is scalable with the inclusion of larger capacity/additional magnetrons and wider wave guides.   
 - the microwave heating efficiency is between 50% and 60%.   
   
 task 5.3: compression moulding using conduction preheating of lft dough   
   
 the objective of this work package was to investigate the feasibility of self-reinforced pellets in an lft dough process. within this task it was demonstrated that the processing of srp pellets in a lft dough process chain is feasible.   
   
 task 5.4: mecanical and physical characterisation of composite panels   
   
 in order to evaluate the level of success of the various material and moulding combinations generated by the project it was necessary to carry out tests to benchmark against current, non-reinforced or none-srp variants and to compare results of the modified composites in order to optimise them.  
   
 the conclusions were:  
   
 - srp materials can be processed on conventional injection moulding machines although care should be taken that the fibres should not be subjected to excess heat and shear. the following settings are advised for optimal mechanical properties:  
 - very slow feeding speed   
 - low back pressure, although some may be useful in dispersing the fibres.  
 - flat temperature profile. advised processing temperatures:  
   
 a) pp matrix: 170-180 â°c.   
 b) pbt matrix: 230 â°c.   
 c) lpet matrix: 180-190 â°c.  
   
 - a slow to medium injection speed should be used.  
 - a large diameter nose, sprue, runners and gates are advised.   
   
 task 5.5: processing of complex shapes   
   
 related to task 5.4, this task gathered the knowledge of specific processing limitations and guidelines necessary for the ultimate end users for the design of components and tools suitable for srp injection. in summary the conclusions were:  
   
 - the processing windows for plastification and injection are significantly influenced by nozzle, gating and cavity design.   
 - the performed studies showed that an exact temperature management is crucial for repeatable properties in the part.   
 - a very low shear management for srp during plastification and injection by using low screw and injection speeds prevent part ...

# INFUCOMP

Project Acronym: INFUCOMP

programme & topic: FP7-TRANSPORT AAT.2008.1.1.2.;AAT.2008.4.1.5.

Most frequent returning words in objectives:

* ('infusion', 5)
* ('composites', 4)
* ('simulation', 4)
* ('resin', 3)
* ('technologies', 3)
* ('aerospace', 3)
* ('performance', 3)
* ('liquid', 2)
* ('materials', 2)
* ('scale', 2)
* ('project', 2)
* ('manufacture', 2)
* ('focus', 2)
* ('industry', 2)
* ('executive', 1)
* ('summary', 1)
* ('today', 1)
* ('layers', 1)
* ('plies', 1)
* ('pre-pregs', 1)
* ('form', 1)
* ('laminate', 1)
* ('textiles', 1)
* ('prepreg', 1)

executive summary:  
today, advanced composites use either layers of plies impregnated with resin (pre-pregs) to form a laminate, or liquid composites moulding (e.g. rtm) of dry textiles. prepreg composites give superior mechanical properties due to toughened resins and high fibre content, but suffer from high material costs, limited drapeability, complex, expensive and time consuming manufacturing, and limited materials shelf life. infusion technologies can overcome these limitations, but are not fully industrialised and rely on costly prototype testing due to the lack of simulation tools. current infusion simulation technologies are approximate and really only suited to small scale components based on adaptations of resin transfer moulding simulation; they are not accurate for large, thick and complex aerospace composites, where one sided tooling and vacuum membranes cause complex 3d heat/flow processes.   
the infucomp project will develop the full simulation chain from preform design to manufacture (infusion), process/part optimisation and final part defects/mechanical performance prediction with a focus on the infusion step. the project covers all popular liquid resin infusion (lri) methods currently used in the aerospace industry. although focus is on aerospace applications, the work will be very relevant to other industries. the proposed technologies will allow economical manufacture of high performance, integrated, large scale composite structures; thus, positively contributing to their increased use. benefits include lower cost, improved performance, greater payloads and fuel/emissions reductions.   
a team of four aircraft manufacturers, a materials manufacturer, university and industry researchers, and a commercial software specialists; all with a recognised track record in this field; one partner is an sme.

# TENDON REGENERATION

Project Acronym: TENDON REGENERATION

programme & topic: FP7-PEOPLE FP7-PEOPLE-2009-IAPP

Most frequent returning words in objectives:

* ('project', 15)
* ('work', 9)
* ('tendon', 7)
* ('regeneration', 6)
* ('engineering', 5)
* ('development', 5)
* ('resilin', 5)
* ('galway', 5)
* ('industry', 4)
* ('biomaterials', 4)
* ('vitro', 4)
* ('package', 4)
* ('collagen', 4)
* ('huji', 4)
* ('human', 4)
* ('scaffolds', 4)
* ('developed', 4)
* ('society', 4)
* ('description', 3)
* ('tissue', 3)
* ('textile', 3)
* ('university', 3)
* ('appropriate', 3)
* ('results', 3)

a summary description of the project objectives  
tendon regeneration â targeting functional tendon regeneration using a loaded biomimetic scaffold: an integrated pan-european approach, was an fp7 marie curie, industry academia partnerships and pathways funded award. completed in august 2014, the project aimed at developing technology, which would enable functional regeneration of injured or degenerated tendons. the project team, comprised of three academic and three industry partners, effectively collaborated and harnessed complementary skills and knowhow in biomaterials and tissue engineering, in vitro and in vivo analyses, textile engineering and new product development for the development of a novel biomimetic (collagen/resilin-based) three-dimensional fibrous composite for functional tendon regeneration. the funding model allowed for staff secondments ensuring transfer of knowledge between industry and academic partners, while ensuring funded fellowsâ career development through inspectoral experience and targeted training. in total twenty-two researchers were directly supported and 255 person months were completed over the four-year project.  
  
a description of the work performed since the beginning of the project  
the work programme was divided in four work packages, which are briefly described below:  
work package 1: collagen and resilin production  
the national university of ireland, galway (nui galway) and vornia biomaterials (vn) extracted, purified and fully characterised atelo-collagen from bse-free bovine achilles tendons, suitable for biomedical applications.  
the hebrew university of jerusalem israel (huji) and collplant (cp) joined forces to successfully express human recombinant resilin in e. coli. after appropriate optimisation and subsequent purification steps, human recombinant resilin of sufficient purity was produced.  
  
work package 2: fibre fabrication, stabilisation and functionalisation  
researches at nui galway, vn, huji, cp, bolton university (bu) and north west textile network (nwtexnet) harmonically collaborated to develop a collagen and a collagen / resilin composite, which was optimally stabilised with various cross-linking methods (e.g. starpeg system, genipin, edc/nhs) and effectively functionalised with various therapeutic and bioactive molecules, including hyaluronic acid, il10 / decorin genes.  
  
work package 3: in vitro and in vivo evaluation of the fibrous composite  
following production of the various scaffolds, extensive in vitro analysis was carried out at nui galway, vn, bu, cp and huji. specifically, surface morphology was assessed with scanning electron microscopy. differential scanning calorimetry was employed to assess thermal properties. tensile testing was used to assed mechanical properties. the cytocompatibility of the produced scaffolds was assessed using human dermal fibroblasts, human tenocytes and rat tendon stem cells. the clinical relevance of the produced materials was assessed in a tendon preclinical model at huji.  
work package 4: scaling up of prototype  
a collaborative effort between bu, nwtexnet, nui galway and vn resulted in a continuous, laboratory-scale, extrusion system, using principles from engineering and textile technologies.  
  
a description of the main results achieved so far, and the expected final results and their potential impact and use (including the socio-economic impact and the wider societal implications of the project so far).  
the tendon regeneration project represents a paradigm in maximum outputs per budget and time available. specifically:  
researcher training: 21 researchers were trained in cutting edge research and development and equipped with appropriate knowledge from both academic and industry setting, increasing their career prospects.  
technological: collagen; resilin; composites of thereof; and functionalised scaffolds were developed. further, methods to maintain tendon-derived cell phenotype in vitro were also developed. continuous extrusion systems that facilitate scaling up and consequently commercialisation of fibrous composites were also developed.  
scientific: the consortium has already published five papers in high impact factors journals, e.g., trends in biotechnology, journal of tissue engineering and regenerative medicine. one further is under submission and ten in preparation. results of this work were also presented in numerous tier 1 international conferences and meetings, including, but not limited to tissue engineering and regenerative medicine society, european society for biomaterials, society for biomaterials, orthopaedic research society.  
societal: the project has made significant progress towards development of functional three-dimensional scaffolds for tendon repair and regeneration, a clinical need with a mounting 200,000 new clinical cases worldwide. having reached technology readiness level 4 within the project timeframe, we anticipate that with subsequent funding the developed technologies will reach clinical translation and commercialisation within 4-5 years.  
  
please include also, as appropriate, diagrams or photographs illustrating and promoting the work of the project, the project logo and relevant contact details.   
the project logo has been included as an attachment.   
   
project coordinator:  
dr dimitrios i. zeugolis  
email: dimitrios.zeugolis@nuigalway.ie  
project manager:  
dr oonagh dwane  
email: oonagh.dwane@nuigalway.ie  
the address of the project public website should also be indicated, if applicable.

# TEXTILE

Project Acronym: TEXTILE

programme & topic: FP7-IDEAS-ERC ERC-SG-SH5

Most frequent returning words in objectives:

* ('project', 5)
* ('material', 4)
* ('research', 4)
* ('textile', 4)
* ('textiles', 3)
* ('medium', 3)
* ('arts', 2)
* ('culture', 2)
* ('meanings', 2)
* ('themes', 2)
* ('field', 2)
* ('public', 1)
* ('interest', 1)
* ('technology', 1)
* ('metaphor', 1)
* ('domain', 1)
* ('history', 1)
* ('past', 1)
* ('decade', 1)
* ('judging', 1)
* ('projects', 1)
* ('publications', 1)
* ('time', 1)
* ('economy', 1)

public, artistic, and scholarly interest in textiles as medium, material, technology, and metaphor has increased significantly in the domain of the arts and of art history in the past decade, judging from recent art historical research projects and publications. at the same time, in an age of global art and economy, textiles have gained an important presence in mass culture. the project directly addressed this multifaceted material and the symbolical meanings of the textile medium. as such, it touched upon related core concepts such as fabric, transparency, flexibility, opacity, veiling, clothing, canvas, network, ornament, or skin, specific to this artistic material. thus, the project explored the universality of textile themes and techniques in paintings, sculptures, installations, and videos, ranging from the middle ages to the contemporary period. taking into account such subthemes as for example the myths of the origins of the textile medium, gender specificities, or spatial meanings, the field of research themes extended the traditional scope of investigations on the textile, treated as cultural phenomenon in the field of craftsmanship. moreover, textiles are everyday-life objects and thus open the door to a theme accessible to an audience crossing cultures and social backgrounds. thus, the project was able to share contemporary scientific and cultural concerns and debates with a greater number of people interested in material culture, applied and fine arts, or working as designers and architects. during the lifetime of the project, several monographs and dissertations as well as numerous articles were written and published. since the project aimed also at strengthening the scientific dialogue and the social competences within the interdisciplinary research community, several networks and exchange platforms were established by the means of conferences, workshops, expert meetings, excursions, research stays, and guest presentations.

# TEXTILE

Project Acronym: TEXTILE

programme & topic: FP7-IDEAS-ERC ERC-SG-SH5

Most frequent returning words in objectives:

* ('project', 5)
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* ('meanings', 2)
* ('themes', 2)
* ('field', 2)
* ('public', 1)
* ('interest', 1)
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* ('metaphor', 1)
* ('domain', 1)
* ('history', 1)
* ('past', 1)
* ('decade', 1)
* ('judging', 1)
* ('projects', 1)
* ('publications', 1)
* ('time', 1)
* ('economy', 1)

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# CUVITO

Project Acronym: CUVITO

programme & topic: FP7-NMP NMP.2010.1.2-4

Most frequent returning words in objectives:

* ('copper', 56)
* ('nanoparticles', 47)
* ('project', 28)
* ('cost', 19)
* ('functionalisation', 19)
* ('synthesis', 19)
* ('process', 18)
* ('silsesquioxane', 18)
* ('cunps', 18)
* ('production', 16)
* ('scale', 16)
* ('textiles', 16)
* ('partners', 15)
* ('silsesquioxanes', 15)
* ('activity', 15)
* ('methods', 14)
* ('nanoparticle', 13)
* ('number', 13)
* ('coatings', 12)
* ('route', 12)
* ('technology', 11)
* ('cunp', 11)
* ('properties', 11)
* ('treatment', 11)

executive summary:  
the cuvitoâ¢ project was a collaboration between eu and mexican partners under the nanomaterials and processes call of the european seventh framework programme (fp7). the over-arching project objective was to bring together mexican mining products and european product development to produce a state-of-the-art copper nano-structured coating. the intended application of the coating was for use in anti-microbial activities within hospitals and other relevant applications. anti-bacterial silver coatings are available; however they are not used in hospitals due to cost, effectiveness and durability. copper offers a low cost, effective and environmentally friendly solution that could be readily adopted. the challenge that was identified was to retain copper nano-particles in a structure that provides antibacterial functionality, but prevents leaching.   
  
the specific aims and objectives of the project were to:  
â¢ develop a copper nano-particle production process capable of producing functionalised nano-particles cost effectively  
â¢ functionalise silsesquioxanes with copper using vitolane technology, targeting 90% functionalisation  
â¢ produce a commercially acceptable coating  
â¢ validate coating in a hospital environment with a target to reduce hospital acquired infections by10%.  
  
through close collaboration between the consortium partners, a cost-effective method for manufacturing copper nano-particles on a commercially viable scale has been developed that is currently being scaled-up from a laboratory environment to a batch production level. the cuvitoâ¢ consortium has developed a silsesquioxane structure, formed using vitolane technology, in combination with various different approaches to functionalisation to develop copper nano-particle based products.   
  
protection of the results of the project is being conducted through six patent applications (3 in europe and 3 in mexico) whilst the following products have been identified for commercial exploitation:  
  
1. copper nanoparticle production.  
2. functionalised stã¶ber sphere (nanoparticle) production.  
3. additive system/coating solution.  
4. anti-microbial coating:  
a) polyurethane based.  
b) epoxy based.  
c) acrylic based.  
d) polyester based.  
5. copper nanoparticles integrated into polymer fibres.  
6. biosensors.  
  
project context and objectives:  
the european centre for disease prevention and control (ecdc) has calculated that the annual number of patients in the eu with at least one hospital acquired infection can be estimated at 4.1 million patients, equivalent to one in twenty hospitalised patients. since patients sometimes acquire more than one infection during the same hospitalisation, the yearly number of acquired infections is estimated at 4.5 million. every year, approximately 37,000 deaths are thought to be caused directly by hospital acquired infections; an additional 110,000 deaths occur annually in which such infections are a contributory factor (1).   
  
copper and silver nanoparticles exhibit antimicrobial behaviour which may allow materials to be developed that prevent the spread of these infectious agents. whilst silver based coatings are available they are considered to be expensive, and only work under a narrow range of conditions.  
  
the challenge for copper coatings is to restrain the copper nanoparticles (cunps) in a structure that provides antibacterial functionality, but prevents leaching of copper into the environment. the cuvito consortium believes that the silsesquioxane structure, formed using vitolane technology, can provide the answer. the silsesquioxanes will effectively bind the cunp to the substrate of interest and prevent it from accidental release into the environment, whilst ensuring it is available to release ions which will provide the antimicrobial characteristic.   
  
silsesquioxanes have been available for some years but at a prohibitively high cost, due to the complexity of manufacture. vitolane technology represents an alternative, cost effective patented production route which can be readily tailored to incorporate the most appropriate functional groups to bind to the copper to textiles which have been selected as target substrate within the cuvito project. this project is a joint european-mexican project aimed at developing new products for the mexican mining industry. the project partners are:  
  
mexican partners:  
centro de investigacion en quimica aplicada â ciqa  
university of guanajuato  
metal tã©cnica s.a. de c.v.  
  
european partners:  
twi ltd (uk)  
institut fuer neue materialien (germany)   
cyanine technologies (italy)  
thomas swan (uk)   
  
the specific aims and objectives of the project were to:  
  
â¢ develop a cunp production process capable of producing functionalised nanoparticles cost effectively.  
â¢ functionalise silsesquioxanes with copper using vitolane technology, targeting 90% functionalisation.  
â¢ produce a commercially acceptable coating.  
â¢ validate coating in a hospital environment to reduce hospital acquired infections by10%.  
  
the properties required for the antimicrobial coating were considered based on criteria falling into the following categories:  
â¢ scientific.  
â¢ technological.  
â¢ environmental.  
â¢ industrial.  
  
the initial focus of the project was the identification of the most promising technical routes to the fabrication of cunps, including cost analysis. a comprehensive review of cunp synthesis methods has been carried out. the aim was to identify a low cost production route for cunps which are suitable for a further functionalisation.   
  
ranking of the nanoparticle synthesis routes was then undertaken according to parameters such as:  
  
â¢ scalability.  
â¢ risk/hazard.  
â¢ reaction time.  
â¢ cost/availability of the precursors.  
  
laboratory scale fabrication was undertaken and the cunps fully characterised using a range of analytical methods including transmission electron microscopy, x-ray diffraction and fourier transform infra-red spectroscopy. transfer of the synthesis methodology to the industrial partners has occurred and been verified using the same analytical techniques. scaled-up fabrication has also occurred and the analysis of the resultant nanoparticles is underway.   
  
the fabrication of the cunps was complemented by the determination of the feasibility of functionalising cunps using silsesquioxanes and alternative materials such as silane coupling agents. with the target application of textiles as the focus of the project a number of silsesquioxanes have been designed and then fabricated at the laboratory scale for examination and use in functionalisation trials.   
  
the achieved progress was in line with expectations and can be summarised as:  
  
â¢ cunps have been manufactured â multiple synthesis routes have been explored.  
â¢ scale-up trials progressing to develop a process suitable for large scale manufacturing (100 litres).  
â¢ functionalisation methods have been identified and trialled.  
â¢ scale-up of functionalisation methods has been studied.  
â¢ samples of coated textiles have been produced.  
â¢ cunp impregnated fibres have been produced.  
â¢ cunp coatings onto aluminium have been produced.  
â¢ cunp coatings onto stainless steel have been produced.  
â¢ target market of medical textiles has been identified.  
â¢ commercialisation opportunities with large mexican materials fabricator are being explored.  
â¢ commercialisation opportunities for specific cuvito products are being explored.  
  
the following potential impacts were achieved from the cuvito project:  
  
1. the creation of a novel copper-silsesquioxane structure using vitolane technology to give greatly enhanced properties allowing the economic use of copper in biocidal coatings.  
  
2. the cuvito project has created new knowledge in several areas:  
â¢ functional silsesquioxanes produced using the vitolane process.  
â¢ stable cunps with functionality to bond to the silsesquioxanes.  
â¢ a production process capable of producing the cunps.  
â¢ an integrated nanocomposite coating ready for commercialisation (polymer/glass matrix).  
â¢ validation data from hospital field trials.  
  
3. the rapid, effective and permanent biocidal treatment of surfaces across a number of markets, including healthcare and food manufacture and processing.  
  
4. the cuvito product holds enormous potential as a safe, non-toxic alternative to silver based coatings and traditional biocides in the healthcare arena, for work surfaces, medical devices and potentially even flooring and seating in operating theatres, etc.  
  
5. the cuvito project aims to ultimately reduce hospital acquired infections by 10%.  
  
project results:  
the main scientific and technological (s&t) results and corresponding foreground intellectual property was developed within specific work packages by the consortium partners. the s&t work packages:   
wp 1: technology design  
wp 2: synthesis of nanoparticles  
wp 3: functionalisation  
wp 4: coating formulation  
wp 5: coating deposition  
wp 6: coated sample evaluation  
  
at the start of the cuvitoâ¢ project a technology review was undertaken in order to identify and design suitable process routes for the manufacture of copper nanoparticles and systematic experiments. this activity was undertaken as part of work package 1 âtechnology designâ. this involved the design and development of a process route identifying the key process steps from ore extraction to final coating production. these steps were then translated into a systematic experimental approach with tasks being allocated to the relevant project partners.  
  
the approach taken was to design the coating considering the properties the coating must exhibit, then considering in order curing, coating deposition, formulation, functionalization, and nanoparticle synthesis. each of the processing steps were further sub-divided as required. the properties required for the antimicrobial coating were considered based on criteria falling into the following categories:  
â¢ scientific  
â¢ technological  
â¢ environmental   
â¢ industrial  
  
the properties of the coating that were considered included:  
â¢ anti-microbial performance  
â¢ morphology  
â¢ chemical characteristics  
â¢ mechanical/physical characteristics  
â¢ copper ion release rate  
â¢ handling issues  
â¢ cleaning  
â¢ appearance  
â¢ cost  
  
a general process route was designed and included:  
â¢ nanoparticle fabrication route definition  
â¢ functionalisation method selection  
â¢ commercial formulation identification  
â¢ coating method determination  
  
during the design of the process route it was necessary to select a generic substrate for experimental characterisation. as a result of market data and discussion within the project consortium it was agreed that the mexican partners would focus on the functionalisation of synthetic fibers and the european partners would focus on cotton. in addition, coating development was pursued using both aluminium and stainless steel substrates. once the substrates had been identified, it allowed the project consortium to establish a functionalisation route design and selection of potential candidate model systems. in turn, it was then possible to determine likely deposition methods, formulation boundaries, the framework for likely characterisation and evaluation tests of the final product.   
  
as part of the activities of work package 1 a life cycle analysis was undertaken using gabi software to try and benchmark the project technology. four routes were considered for the application of copper nanoparticles (cunp); aluminium, steel and cotton substrates with a coating containing cunp applied to the top surface, and cu/polypropylene textiles produced by melt blending the copper into the polypropylene at the fibre formation stage.   
  
detailed consideration was given to the manufacture of the copper nanoparticles, to the additive manufacture and copper functionalization and to the integration of the copper into thermoplastics such as polypropylene. for the lca, no transportation data was included in the modelling. data for the lca was generated via literature surveys.  
  
it was found that a significant amount of the environmental impact for different product cases were attributable to the nanoparticle synthesis stage. the nanoparticle synthesis was examined only at the laboratory scale, and it is anticipated that scaling up the process is likely to improve this result as would the use of recycled feedstock. the conclusions of this study were that:  
  
â¢ the global warming potential (gwp) of the cotton textile has been calculated to be 23.4kgco2e/kg, and 8.4kgco2e /m2 assuming a 200g/m2 weight of cotton fabric.  
â¢ the gwp of the polypropylene textile has been calculated to be 133.5kgco2e/kg and 5.3kgco2e/m2 assuming a 40g/m2 weight of polypropylene fabric.  
  
as part of the activities of work package 1 a health, safety and environmental assessment was undertaken by the project consortium. a review of the regulatory and legislative framework for nanomaterials and nanotechnology was completed. this identified that there are a number of public bodies involved in the development of new practices, procedures, standards, regulations and legislation for new materials and new working practices. these bodies exist at the national level, at the ec level and also globally. the jurisdiction of these bodies is, unfortunately, not clear. there is also the added complexity between those bodies whose remit is to provide information and guidance and those whose role is to police the regulations.  
  
a full health, safety and environmental assessment for the use of nanomaterials must therefore show that due diligence has been undertaken and the most relevant guidance has been identified and included. this activity had three primary elements:  
â¢ health, safety and the environment regulation  
â¢ standards  
â¢ operational procedures  
  
the conclusion of this investigation was that the standard approaches for risk assessment and material disposal can be used for nanomaterials and, in line with normal practice, need to be specific to the materials and the operational environment. a number of guidance documents and draft standards to allow this specificity to be achieved have been highlighted. it was concluded that specific products being produced under the cuvitoâ¢ project can therefore be provided into the market place with the requisite msds and risk assessment information that could be produced by the supply side project partners based on compliance with existing legislation.  
  
synthesis of nanoparticles  
  
the synthesis of copper nanoparticles was undertaken within work package 2. this activity identified potentially suitable precursors, chemical processing and synthesis methods with the aim of selecting the most appropriate method for low cost, medium volume production of copper nanoparticles. to select the most suitable precursor for fabrication of copper nanoparticles, parameters such as cost and amount used, availability and handling cost were studied to select the appropriate precursor. cuso4 and cucl2 were down selected as the most appropriate precursors.   
  
to find a nanoparticle synthesis route that would allow a cost effective mid-scale production, metal tã©cnica and inm first set up an overview of various syntheses that could be used to produce copper nanoparticles in general. using various evaluation criteria like yield, precursor costs, equipment costs etc. this enabled the number of possible methods to be narrowed down to those that would fit the demands. synthesis routes that were considered included laser ablation, ball milling, photo-reduction, thermal reduction and chemical reduction. from the preliminary investigations, thermal reduction and chemical reduction were selected for the investigation of the thermal decomposition of an organic copper precursor.   
  
investigation of the cunps after manufacture found that it would be necessary to develop a separation and purification process for the purification of the cunps. several methods for the purification of the copper nanoparticles were explored by metal tã©cnica and inm to allow the large scale purification and the removal of the most of the chemical reducing agent. it could be shown that the addition of sodium carbonate during the washing steps in the usually used centrifugation/redispersion washing procedure used at lab scale drastically reduces the amount of organic carbon from values above 20% by weight to values below 0.2% by weight. another method of purification that was investigated was a tangential cross-flow system, which allows a simple and easily scalable setup. tests at inm were found to show promising results: the carbon content could be reduced to a sixth compared to a regular dialysis.   
  
in order to scale up the cunp manufacturing process, inm and metal tecnica agreed a fabrication protocol which was replicated in the prototype scale up rig in metal tecnicaâ´s facilities. initially fabrication was undertaken at the small scale (500ml) to confirm reproducibility and establishment of full transfer of the technology followed by fabrication of a 20 litre batch. characterization of the small scale batch confirmed that the obtained particles were of 15 nm with spherical morphology and a homogeneous distribution.   
  
  
initial evaluation of the particles made by thermal reduction and chemical reduction was undertaken by the university of guanajuato. the antibacterial properties of the particles were compared with commercial copper and silver nanoparticles. analysis of cunps was primarily performed by tem and x-ray diffraction (xrd) studies. repetition of testing found that cuso4â¢5h2o was a suitable precursor to produce spherical copper nanoparticles at larger scale with a narrow size distribution between 5 and 20 nm, depending on synthesis conditions. inm conducted several tests on the chemical reduction routine to see the effect of various synthesis conditions on the nanoparticles. precursor concentrations were varied as well as ascorbic acid concentrations, synthesis temperature, stirring speed etc. the optimization results were given to metal tã©cnica for the setup of a large-scale prototype for this synthesis. in all syntheses done during the optimisation, cu was obtained, as xrd measurements corroborate. tem analyses showed that the syntheses yielded spherical nanoparticles in the range of 5 to 20 nm, depending on the conditions. the yields varied, depending on various parameters, like the amount of precursors used or the reaction temperature.  
  
the results obtained by inm allowed metal tã©cnica to set up the prototype with the most promising conditions for a large scale production. the particles produced in the optimization process performed by inm were tested at uog for their antibacterial properties and it was found that their anti-bacterial properties correlated with the carbon content of the nanoparticles.   
  
thomas swan ltd has carried out provisional commercial assessments of the copper nanoparticle production route. inm have supplied thomas swan with several potential outline laboratory synthetic pathways to produce cunps. the cost analysis determined that the chemical reduction route for the manufacture of copper nanoparticles is competitive with commercially available products.   
  
  
functionalisation  
  
at the outset of the project it was recognised that one of the primary s&t challenges would be to functionalise the cunps such that they would be compatible with the carrier system in which they would be used e.g. polymer resins. the work that was performed needed to take account of the different substrates e.g. textiles and metal surfaces as the requirement for treatments on textiles is profoundly different to those of hard surfaces. the project partners agreed that the two generic activities focussing on functionalisation would address different aspects of textile treatments. specifically, the european partners would develop functionalisation methods aimed at the treatment of natural (cotton) textiles, whilst the mexican partners would develop treatments for the incorporation of nano-copper into synthetic textiles.  
  
it had been established that treatments for natural textiles need to be water based to be compatible with conventional processing methods. they also need to ensure that the treatment does not affect the feel or flexibility of the textile whilst imparting the additional attribute required. coatings and textile treatments can generate either very dilute film-forming compositions, which wet onto each filament, but are very deposition method sensitive, or allow the discrete deposition of active agents. to achieve these aims a design review for the silsesquioxane functionalisation molecule was undertaken. a number of silsesquioxanes were designed and then fabricated at the laboratory scale for examination and use in functionalization trials. the specific requirements of the silsesquioxanes were to: a) bond to the copper nanoparticles, b) bond to the surface of the cotton textile, c) have either a film forming capability or to have no film forming capability, d) be dispersible in the appropriate liquid vehicle.  
  
  
the approach taken was to fabricate silsesquioxanes of increasing complexity once an understanding of the synthesis method of simpler functionalities had been established. in the first instance the key functional groups to impart the required attributes needed to be identified, and a number of candidate silane coupling agents were selected as candidates. on the basis of cost, handling hazard, commercial availability and compatibility with the vitolane process (which demands low ph constituents) the (3-mercaptopropyl)trimethoxysilane was selected as the most promising candidate.   
  
laboratory trials were then undertaken to establish a route to the manufacture of a silsesquioxane made solely from this silane, called the thiol-silsesquioxane. once the route to this silsesquioxane was established, the method was provided to thomas swan for scale-up consideration. laboratory scale synthesis of the silsesquioxane was undertaken and a range of analytical and characterisation methods were completed. trials with the thiol-silsesquioxane showed successful functionalization and so this method was chosen as a possible candidate for the large-scale production.   
  
the thiol silsequioxane was determined to have an average molecular weight of 1115g/mol. this was derived from its hplc retention time. this molecular weight indicates that the silsesquioxane is likely to have an average structure containing seven silicon atoms, based on the average molecular weight of the t(2) species of 161. this is broadly consistent with a trisilanol cubic septomer type silsesquioxane.  
  
in addition, two further silsesquioxane fabrication procedures were developed, one of these generated a dual functional silsesquioxane, with the capability of bonding to both copper and cotton textiles, the third silsesquioxane had both these attributes in addition to an additional functional group that would reduce excessive bonding to either of these materials and would allow controllable quantities of the silsesquioxane to be deposited onto the copper nanoparticles.  
  
the multiple functional group silsesquioxanes were then exposed to copper nanoparticles and it was demonstrated that thiol containing silsesquioxane yielded copper colloids in organic solvent, whereas non-thiol based silsesquioxanes gave copper ions via a dissolution mechanism. this shows that the particles are incorporated in an amorphous matrix and are agglomerated, but were capable of being dispersed in ethanol. the thiol based silsesquioxane/copper colloidal suspensions were successfully deposited onto cotton textiles.  
  
process parameters for the scale up of these silsesquioxanes were provided to thomas swan and preliminary costs for larger quantity manufacture were generated. as part of this cost analysis, raw material assessments have made on the basis of far east vs. western supply base and also purchase quantity. brief assessments of supplier company size and security of supply have also been carried out. this data was then fed into cost models for raw material cost comparisons.   
  
in addition to the functionalisation of cunps undertaken using silsesquioxanes, alternative routes to functionalization of copper nanoparticles and copper oxide nanoparticles (ncuo) by different methods was successfully completed. modification and functionalization by silanes, oxidative hydrolysis and nitrogen ligands were carried out simultaneously aiming to obtain a perfect control of size and morphology of the nanoparticles and formation of coating on particle surface. in addition, the inclusion of cunps in acrylic coatings by surface modification using a plasma treatment was successfully completed. successful demonstration of functionalisation was achieved by the production of synthetic textile fibres containing different loading levels of copper.  
  
  
coating formulation  
  
following the manufacture and functionalisation of the cunps it was necessary to consider the development of suitable formulation protocols such that the cunps could be applied into their intended applications. several application methods for the textile functionalisation exist, such as roll-to-roll, immersion or ink-jet processing, as used for the dyeing procedures. also, a plasma treatment is possible. the identification of the best way for implementation into currently used manufacturing processes was completed by pianeta. a water-borne coating formulation was specified as a treatment for textiles, this was to allow industrial adoption based on the common practice of water based inks with a solid content of 2-10% with curing being thermal, typically 150â°c for 5 minutes. for the polypropylene textiles, the approach adopted was to incorporate the copper nanoparticles into the polypropylene melt blend prior to fibre spinning, hence no coating model system was identified.  
  
an epoxy resin system as a model coating for steel substrates was selected. araldite cy 179 is an extremely low-viscosity, reactive diluent free matrix system with a long pot life. this resin displays very good post cure temperature resistance and exhibits good adhesion to steel substrates. a generic model system for an abrasion resistant coating on aluminium was identified. this coating formulation had been developed by sartomer and consisted of uv curable acrylate chemicals. the coating formulation was solvent-free and rapid curing under uv irradiation and so was selected on the basis that it belonged to the most environmentally responsible class of coating formulations. this formulation also did not require a primer treatment and produced an abrasion resistant surface film on aluminium.  
  
  
coatings for steel  
copper nanoparticles (cunp) were added into araldite cy 179, a diluent free matrix system in the range of 0.1 to 2% by weight. in some cases, surface modifiers were tested to potentially increase the redispersibility of the nanoparticles. the particles were stirred for several hours, then a uv initiator was added. stainless steel substrates and glass were coated using spiral bar-coaters with 10-30âµm or applicator frames with 0.1 to 0.5mm. in the case of coatings for aluminium, a number of different formulations were considered, fabricated and deposited on aluminium substrates.   
  
  
coatings for textiles  
for the controlled application of cunp onto textiles, pianeta proposed ink jet technology as this would allow a controlled distribution on the cotton fabric. therefore, it was necessary to develop an appropriate ink based on the thiol-silsesquioxane developed earlier in the project combined with either water or isopropyl alcohol. the visual appearance of the recovered supernatant liquids was an amber coloured liquid whose depth of colour increased as the amount of copper and thiol silsesquioxane in the parent mixture respectively increased and decreased.  
  
additional activity to functionalise the copper nanoparticles were undertaken. these were based on the need for a bidentate ligand, one that could couple to the copper but also to the substrate (cotton). an alternative approach was adopted were separate silica nanoparticles were manufactured, functionalised with a thiol silsesquioxane and then combined with the copper nanoparticle. a number of ink formulations were prepared based on this approach, two were water based and two were solvent based.  
  
a number of methods were used to incorporate copper nanoparticles into polypropylene, these included and included surface plasma modification of copper nanoparticles with different acrylic monomers: acrylic acid (aa), methyl methacrylate (mma) and acrylonitrile (an). during plasma modification, copper nanoparticles were coated with a thin film (5nm) of polymer. preparation of acrylic/copper and epoxy/copper nanocomposites by photo-polymerization was completed by mixing acrylic or epoxy monomers with a photoinitiator and copper nanoparticles. after ultrasonic agitation the mixtures were placed into teflon moulds and exposed to uv light during 3 minutes.   
  
different amounts of commercial copper nanoparticles into polypropylene was carried out by melt extrusion assisted by ultrasound. in this case, the presence of copper nanoparticles generated a green coloration, which increased in intensity with copper concentration.  
  
manufacturing considerations based on the latest understanding of the process flow for the production of copper nanoparticles, silsesquioxane coupling agent and a new silica nanoparticle support agent were evaluated. the materials cost base, process flow considerations and likely batch time reviews were considered. the additive design went through an iterative approach to produce a final refined methodology.  
   
the manufacturing routines are considered as both feasible and suitable for adoption within the manufacturing capability of the cuvito project partners. based on the assumption that the additive is supplied in aqueous suspension at approximately 1% loading, the costs would be allow for a final product price of â¬12-15/litre discussions with those in the textile industry suggest that water borne treatments for dyeing and to provide hydrophobic characteristics are typically sold in this price range. on this basis, it is considered that a commercially viable product can be manufactured and priced at level that would be acceptable to the market place.  
  
coated sample evaluation  
  
the university of guanjuato completed anti-microbial testing of a range of different cu and silver nanoparticle based materials. silver nanoparticle material is being investigated in order to provide comparative data with existing products in the marketplace.   
  
the antimicrobial activity of polypropylene/silver (pp/ag) and polypropylene/copper (pp/cu) nanocomposites has been investigated in order to evaluate the effect on this activity when the nanoparticles were exposed by argon plasma treatment. the antimicrobial properties were evaluated on pathogenic bacteria s. aureus and p. aeruginosa. antibacterial activity against s.aureus after different time of interaction with untreated cu nanocomposites and plasma treated (1, 3 and 6 hours) has been demonstrated. the antimicrobial activity was related directly to the amount of nanoparticles in the polymer. plasma treated nanocomposites presented a significant increase of their antimicrobial activity, due to the fact that nanoparticles were directly exposed to the surface by the argon plasma treatment.   
  
by comparison antimicrobial activity against the gram (-) p. aeruginosa presenting a higher antibacterial effect than on s. aureus. the same effect is observed were the plasma treatment increases their antimicrobial activity. according to these results, the nanoparticles exposure at the surface of polymer nanocomposites by argon plasma treatment was decisive to obtain high antimicrobial properties at lower contact time, thus enhancing the surface properties and the functionality of polymer nanocomposites.  
  
the antimicrobial activity of a number of additive samples containing cu nanoparticles synthetized by inm and functionalized using mercapto silsesquioxane by twi have been investigated. commercial functionalized cu nanoparticles were also evaluated. all the samples were prepared in water as well as in isopropyl alcohol (ipa). antibacterial activity against s. aureus for the samples containing cu nanoparticles without mercapto silsesquioxane prepared in water was evaluated. the commercial cu nanoparticles had low antimicrobial activity even after 60 min of interaction reaching a maximum of 39 % of antimicrobial activity aga ...

# RAPTOR

Project Acronym: RAPTOR

programme & topic: FP7-SECURITY SEC-2007-1.2-02

Most frequent returning words in objectives:

* ('protection', 42)
* ('fabric', 33)
* ('security', 31)
* ('fibre', 22)
* ('fibres', 22)
* ('weight', 18)
* ('performance', 18)
* ('development', 17)
* ('layers', 17)
* ('project', 16)
* ('scenarios', 15)
* ('aramid', 15)
* ('fabrics', 15)
* ('hand', 13)
* ('structure', 13)
* ('demonstrator', 13)
* ('results', 13)
* ('yarns', 13)
* ('yarn', 13)
* ('generator', 12)
* ('textiles', 11)
* ('resistance', 11)
* ('threads', 11)
* ('weft', 11)

executive summary:  
raptor was a collaborative project funded by the european commission. the project involved 5 partners from 3 european countries, and had a total funding budget of around 2 million â¬. it was carried out over a period of 48 months from january 2010 to december 2013.  
the aim of the project was the development of innovative and integrated, mobile and rapid deployable, gas generator assisted inflatable structures for the ballistic protection of european civilians against security scenarios, such as crime and terroristic attacks. tailored solutions have been developed based on the scope (e.g. the prevention of, or the response to security scenarios by european security forces, such as protection of special persons or general security of events), including inflatable ballistic structures for the protection of:   
â¢ individuals  
â¢ groups of 2 â 5 persons (carried in trolley, back pack, etc.)  
â¢ general security of events (transported in car boot, by pick-up, truck, etc.)  
the concept was based on the fact, that not only heavy weight metal or light weight composites armouring, but also loose layers of aramid fibre fabrics can stop a bullet. the application area of the proposed protection device is strictly for civil application. scenarios of european security forces contain threats from hand held guns or improvised explosive devices (ied), which have much lower ballistic performance than military equipment e.g. machine gun or mortar grenade. however, a fast response should enable a rapid deployment which should by the inflation of the gases from gas generator as used in airbags for cars.  
the investigations included an outline of the threat scenarios which identified a list of situations where such a ballistic protection kit was urgently needed for improving security of individuals ending up with specifications. predominantly, 2-3 persons have to be protected against the attack by hand guns and hand grenade and enable a counter attack from this safe area.  
the ballistic protection was established by a multitude of textiles layers made out of aramide fibres. the fibre weaving applying various methods, treatment by lamination and their combination was optimized by measuring the energy reduction of various layers to achieve best resistance against the impact of the selected ammunition. the assumed effect of loose hanging fibres was disproved for this application ending with compacted textile layers. for the inflation of the ballistic package new approaches for the gas generator formulation and manufacturing techniques were needed. it combined pyrotechnic hot gas production with ablative cooling to provide cool gases for safely deploying the folded protecting shield stabilized by inflated tubular structure. finally, all components were combined in a demonstrator which was tested on a shooting range. the results showed that the ballistic shield deployed in a short time and withstood the demanded impact of bullets, fragments and blasts according to the specifications.   
the exploitation considers the innovative results of the developed components of the demonstrator, which will be also individually used. the basic project concept was concluded, has been summarized on the demonstrator and its functionality has been successfully tested. the demonstrator is planned to be further developed to be a protection kit available for future law enforcement by security forces. as the raptor demonstrator at the end of the project is a functional prototype rather than a ready to use prototype, the question of further financing/further project work was addressed. fundamentally, the possibilities will be considered and national research funds (e.g. in germany: bmbf = bundesministerium fã¼r bildung und forschung = federal ministry of education and research), from european funds (horizon 2020) or via a self-funded financing by demand of industrial partners as well. the dissemination of the results has been discussed and restricted issues respecting to the end user bka will be respected.  
  
project context and objectives:  
research on security is a main issue in europe to improve measures for protection of its inhabitants against manmade disasters or those induced by natural events. specifically, terrorism has strongly threatened people at all scales of dimensions in the recent years. the context of the project concerns the protection of individuals or small groups against direct attack by weapons.  
the overall objective of the project was the development of innovative and integrated, mobile and rapid deployable, gas generator assisted inflatable structures for the ballistic protection of european civilians against security scenarios, such as crime and terroristic attacks. depending on the scope tailored solutions have been developed, including inflatable ballistic structures for the protection of:   
â¢ individuals  
â¢ groups of 2 â 5 persons (carried in trolley, back pack, etc.)  
â¢ general security of events (transported in car boot, by pick up truck, etc.)  
  
the entire spectrum of personal protection gives rise to a large number of situations and sequences of actions which the relevant task forces of the bka deem to be critical. a clear distinction has been drawn between situations of daily importance and special scenarios like public appointments, pre-election campaigns, state visits or conferences, as well as travel movements of the protected person both at home and abroad. essentially, personal protection is influenced drastically and rendered more difficult by the following factors:  
â¢ lack of material protection on the way from one secure area to another by foot  
â¢ entry / exit of e.g. armoured vehicles  
â¢ event locations (indoors and outdoors), where a huge audience is present and not every member of the audience can be completely inspected  
â¢ spontaneous route changes of the protected person  
â¢ speakerâs desks in the immediate vicinity of uncontrolled spectator masses  
â¢ strict protocol regulations and / or limited resources  
â¢ lack of suitable resources and partly different security standards for personal protection measures abroad  
  
for this potential risks a solution has to be developed with respect to:  
â¢ providing a shelter in case of an attack  
â¢ attacking the aggressor from a covered position  
â¢ ensuring safe evacuation of the protected person  
based on the listed scenarios, specifications for the development of the security kit were defined and criteria for the demonstration of their effective performance derived. the most flexible and realistic appearance of the security kit is a trolley-like housing.   
the demands of the security kit were based on the requirements of ballistic protective vest level one. blast-impeding properties were required to minimize the effects of a fragmentation hand grenade, i.e. the side of the security kit facing the blast must neither be penetrated by primary nor secondary fragments that could endanger any person behind the wall. the demonstrator proved the protecting performance of the shelter. predominantly, 2-3 persons can to be protected against the attack by hand guns and hand grenade and enable a counter attack from this safe area.  
  
potential security scenarios included mobile security kits, such as:  
- briefcase/backpack for 1 person,  
- trolley/suitcase for 1-5 persons,  
- tent (e.g. on pick-up truck or in a soccer stadium under the floor) for bigger crowds  
- âred carpetâ tunnels  
- inflatable fences, and  
- inflatable curtains  
   
the application area of the proposed protection device is strictly for civil application. scenarios of european security forces contain threats from hand held guns or improvised explosive devices (ied), which have much lower ballistic performance than military equipment e.g. machine gun or mortar grenade.  
the objectives of the project were two fold â the development of the high performance flexible ballistic textile systems and the gas generation for inflation a stable structure to deploy the protection unit in short time.  
  
the objectives of the ballistic textile system development included:  
â¢ selection of high performance textile yarns to characterize their strengths and drawbacks according to the specified scenarios and ballistic calibres  
â¢ development of fabric weaving / coating technology to end up with a high performance fabric to enable high ballistic protection in combination with a light weight structure to realize fast deployment times like in airbag systems  
â¢ development and design of the ballistic protection structure concerning the requirements, e.g. light weight by combination of different fabrics and special coatings, number of fabric layers etc., according to the selected ballistic calibres  
â¢ development of gas tight support structures of tube like form to enable on the one hand fast deployment and on the other hand long holding time (> 3 hours) of the structure  
â¢ design and testing of different folding pattern concerning reliable structure deployment and small package volume as in airbag systems  
  
pyrotechnic gas generator compositions used in airbag systems provide a huge amount of non-toxic gas within milliseconds. the solid compositions consist of a fuel and an oxidizer and are usually pressed in pellet shape. the gas is generated by a combustion reaction.   
  
the objectives of the gas generator development were:  
â¢ selection of basic components of the pyrotechnic composition according to high gas yield above 400 dmâ³ per kg composition, non-toxic gas composition and low combustion temperature (below 2000 â°c)  
â¢ processing and shaping of compositions according to necessary gas production rate and safety parameters  
â¢ characterization of the combustion behaviour under pressure and the combustion temperature to select compositions with high combustion rates and low temperature  
â¢ design and development of the pellet shape to provide adjusted gas production enabling fast and reliable deployment of the fabric structure  
â¢ design and development of cooling agents reducing the gas temperature down to ambient conditions  
â¢ development and testing of the pyrotechnic gas generator combustion chamber in combination with the cooling agent to realize reaction times of the total system below 1 second  
the development of both basic systems was performed in parallel based on the elaborated specifications.  
objectives for protection were based on results of current approaches of individuals against fire of hand guns (soft-ballistics) which use clothing like helmets, vests or movable bullet-proof shields. there have been investigated effective ballistic fibres show high youngâs modulus, tenacity and elongation at break consist of p-aramides (twaronâ®, kevlarâ®) or umhwpe (dyneemaâ®, spectraâ®), an ultra-high molecular weight polyethylene. some typical products for military or automotive industry personal protection are laminates (in most cases plates or soft-shaped preforms) was took into account consisting of ballistic fabrics and polymeric binders or multiple-ply packs with several layers of textiles stitched together. standard textiles used for anti-ballistic applications were fabrics: twaronâ®, for example, offers a variety of p-aramide fabrics with different weaves like plain, basket or twill.  
  
in regard to official events, where outstanding persons have to be protected the concept of the mobile security kit follows the idea that a rapidly deployable unit leads to a surprising moment to the offender and that for a short period of time the single person or group to protect is hidden and counter measures by the security forces can come into action. objective of the deployable kit was to complete the protection of persons that are wearing protective clothing because of the fact that strikes on bullet-proof vests can cause serious injuries to the wearer like blunt traumata. in opposition to mobile protection kits like shields, inflatable tents or tunnels can protect persons from bullets coming from more than one direction and the position of the victim still remains invisible for the shooter. last but not least more than one person can be protected from gun shots. because of the possibility to deploy curtain-like structures with several layers of loose anti-ballistic fabrics hanging down in defined distances, a so called towel-effect has been verified  
with the additional specification of foldability - especially the ballistic textiles - havebeen constructed (stile of weave) and coated in that way that the single layers do not stick together and are resistant to creasing tendency. a second progress in textile modification beyond the state of the art was the development of textiles that meet the requirements of airbag application and that are stiff and airtight enough to maintain the specified shape desired time scales.   
finally, the gas generator for rapid inflation had to deploy the frame of the ballistic protecting device within its selected time scale. the security kit demonstrator was tested close to real conditions.  
  
project results:  
research on security in europe is a follow-up manmade disaster or those induced by natural events. it has to improved measures for protection of european inhabitants by innovative approaches. terrorisms evolved as threat strongly endangering people at all scales of dimensions in the past years. the project contributes to the need of protection of individuals or small groups against direct attack with weapons in exposed scenarios. it should develop a security kit which enabled a mobile and rapid deployable structure of a ballistic protection shield for european civilians against threat of a direct attack by weapons.   
  
4.1.3.1 scenarios and derived specification for the security kit  
the entire spectrum of personal protection gives rise to a large number of situations and sequences of actions which the relevant task forces of the bka deem to be critical. a clear distinction between situations of daily importance and special scenarios like public appointments, pre-election campaigns, state visits or conferences, as well as travel movements of the protected person both at home and abroad have been considered.   
to close lacks of security, firstly a trolley-like solution with a ballistic protection and fast deployment was considered to be a potent possibility as an additional personal security resource. with aid of such a ballistic protection device, the possibilities to provide a short-time shelter and to evacuate the protected person would be largely enhanced. furthermore, the aggressor can be fought off.   
the device developed in the raptor project has the potential to come to use in a multitude of situations to prevent terror and crime against european citizens and to increase their safety in many different threat scenarios.  
  
based on the above listed scenarios, specifications for the development of the security kit are defined and criteria for the demonstration of their effective performance derived. the most flexible and realistic appearance of the security kit is a trolley-like housing. therefore, the needed technical requirements which were derived analysing the treats are listed below:  
â¢ appearance: commercial travel trolley, divert attention  
â¢ transportable on airlines, motor vehicles and ocean liners  
â¢ total weight including ballistic package, support structure, gas generators and housing: maximum 15 kg  
â¢ manual triggering (one-handed operation)  
â¢ remote triggering with a max. reach of up to 10m  
â¢ ballistic protection in accordance to specifications   
â¢ protective space should be semi-circular  
â¢ protection kit height: 170 cm, width: 200 cm  
â¢ provides shelter for 2 â 3 persons  
â¢ durable, fixed position after unfolding   
â¢ possibility of shifting the deployed unit by carrying handles  
â¢ minimum time in fixed position: 30 seconds  
â¢ security package unfolds with the speed of an airbag  
â¢ insensitive to extreme temperature fluctuations (-35â°c to +85â°c) and shocks  
â¢ minimized danger during unfolding (brute force, burning, noise)  
the guideline has to be interpreted flexibly. for instance, the set-up of ballistic measurements complying with the directives leads to higher bullet velocities compared to ballistic measurements performed with handguns. for the project certain deviations should be accepted concerning the bullet velocities defined by the vpam guideline. special emphasis will be put on the kinetic energy on target. this energy should be as many as 500 joule (see above listed ballistic requirements). this value can be achieved with handguns as well. blast resistance should include stable protection against a hand grenade  
  
4.1.3.2 ballistic protection textiles  
the main components of the protection kit are the ballistic protection textiles. its development required the research, selection and modification of applicable fibres, yarns, fabric designs and fabric coatings for ballistic applications. a primary question in this context was about the protection level that best meets the threat scenario requirements.   
another important question was about which synthetic fibres could be applicable for ballistic protection. in several literature and product researches it was found that ideal antiballistic fibers for composite purpose have following profile (cunniff , auerbach, vetter and sikkema):  
â¢ high tensile and compressive modulus   
â¢ high tensile and compressive strength (in composite form),  
â¢ high damage tolerance,  
â¢ low specific weight,  
â¢ good adhesion to matrix materials (for structural composites only) and  
â¢ good temperature resistance.  
  
as high degree of molecular orientation results in high tensile modulus and strengths but also in a loss of these properties transverse to the fibre axis bending or compression loading of high oriented fibres should be avoided and therefore they should be pulled parallel to their axis.   
the research on applicable fibres and yarns for anti-ballistic purpose started with a general view of those types of fibres that are used in composites, most commercially available and, in terms of ballistic protection, interesting.  
following fibres e and s-glass, wire/chain mail, wire/e-glass, aramid (twaron/kevlar), aramid auxetic, aramid with wool, carbon, uhmwpe (dyneema/spectra), pbo (zylon) poly(p-phenylen-2,6-benzobisoxazol), pipd(m5 poly {diimidazo pyridinylene (dihydroxy) phenylene}) for antiballistic purposes have been tested and established or are about to come into use. there were experiments performed with diverse fibres types but aramid fibres are described in more detail:  
para-aramid fibres (kevlarâ®, twaronâ®, technora â®)  
para-aramid fibres are widely used in ballistic protection applications because of high properties and low density the values the sound velocities last from ca. 600 to 680 m/s. on the market of para-aramid fibres exist two leading companies: dupont (kevlarâ®) and teijin (twaronâ®). a further p-aramid fibre of teijin technoraâ® is not used for antiballistic applications.  
properties of para-aramid fibre  
  
chain molecules longitudinally orientated with paracrystalline structure and covalent bonds give  
â¢ high tensile strength and modulus  
â¢ high thermal stability and glass transition temp. (tg)   
â¢ high dimensional stability (low creep)   
â¢ non-brittle and high impact resistance  
â¢ good abrasion resistance  
â¢ high chemical resistance except strong mineral acids  
â¢ low dielectric constant  
â¢ poor resistance to uv radiation  
â¢ poor compressive resistance due to defibrillation   
â¢ absorbs up to 4,5 (5) % moisture by weight  
in the fibre selection process mehler uk stated that aramid fibre, either from dupont or teijin would be better than high molecular weight polyethylene because of the poor temperature resistance of dyneema, limited to a maximum of 70âºc. of the fibres from dupont, kevlar 29 would be his first choice and this is generally cheaper than kevlar 49 although good results had also been achieved with both fibre types. the twaron ct microfilament yarn from teijin introduced a few years ago was expected to give significant ballistic improvements however, this did not turn out to be the case and there is little to choose between the products from dupont and teijin.  
  
forms of fibres and yarns  
beside the question about what materials were used for fibres and further for fabrics one should give a short overview about different fibre forms and the use these forms.  
high performance fibres are generally used in one of four forms:  
â¢ staple fibre, 1 to 15cm long, usually spun into yarn  
â¢ chopped fibre, cut to short,specific length, often added to matrix  
â¢ monofilament , a single, large, continuous filament  
â¢ multifilament, extruded continuously with many filaments  
  
fibres were processed for use into one of four forms:   
â¢ yarn or roving for further use  
â¢ non-woven fabrics  
â¢ woven fabric  
â¢ knitted fabric  
yarn or roving for further use  
multifilament yarns are plied or twisted together and are used e.g. for sewing threads or ropes. rovings are â.long and narrow bundles of fibres.â (http://en.wikipedia.org), obtained either directly in primary manufacturing or by combining multiple threads together without any twist. they are used for filament winding processes for pipes, pressure cylinders or to make unidirectional reinforcements, either as fibre or woven fabrics.  
yarns for anti-ballistic applications  
an enhancement of the yarn strength can be achieved by increasing the twist .yarns for anti-ballistic fabrics are slightly twisted because they consist of endless filaments and not of staple fibres and only have to be hold together by twisting.   
yarns for blast resistance - auxetic yarns  
the use of auxetic yarns is being considered. fabric woven with this yarn type was tested as part of the eu-funded >>flybag project<< . this was a blast and fragmentation retaining device to protect aircraft from explosions in the cargo compartment. see below slides for explanation of the action of this type of yarn.  
  
weaving has a strong impact on the ballistic performance. it involved the following types with the listed results:  
â¢ weaving of auxetic yarn  
o liaising with stfi for information on fly-bag project, blast control  
o sourcing auxetic yarn from dr. hook of auxetix  
o setting up loom to weave auxetic yarns across a wire/glass warp   
â¢ weaving and supplying mock leno fabric samples to test âchain-mailâ effect  
o novel fabric to simulate effect of chain mail in ballistic tests  
o principle of âanisotropicâ fabric could be developed further  
â¢ weaving samples of fabric with zylon hm and dyneema sk65and sk90 weft yarn  
o sourcing samples of the test yarns  
o setting up loom to weave these high performance yarns not previously attempted   
â¢ weaving and supplying 1,000m of 05471/170cm for manufacture of final demonstrators  
o sourcing yarn and organising warp manufacture  
o overcoming problems experienced weaving panama construction at 170cm width  
  
for ballistic tests there were panels woven supplied to fraunhofer ict:  
â¢ 50 x 2m panels 05471 woven at sherborne  
â¢ 22 x 2m panels dyneema sk 65 weft  
â¢ 22 x 2m panels dyneema sk 90 weft  
â¢ 22 x 2m panels zylon hm weft  
â¢ approximately 150m warp yarn left on beam for weaving more of above fabrics or additional leno samples depending on results of ballistic tests.  
  
for the final demonstrator the following criteria were found using also the results of the next chapter:  
â¢ fabric type: style 05471, aramid 1680dtex warp and weft, ends x picks 12.6 x 12.6/cm, panama weave, weight 410g/m2   
â¢ fabric width: 170cm wide to remove requirement for seams in ballistic shield but giving sufficient height for protection  
â¢ production quantity: 1,000 linear metres woven will allow production of 10 to 12 demonstrators, each demonstrator requiring approximately 85lin.metres  
âpanamaâ weave similar to âplainâ weave but has two warp threads weaving in parallel together and two weft threads to be inserted side by side in each opening of warp threads.   
owing to increased width of 170cm, problems caused by first inserted thread being dragged out of position by âsuctionâ of reed moving rapidly backwards since warp threads are held open to allow second weft thread to be inserted. not a problem at narrower 107cm width   
problem overcome by use of leno-locking mechanism mounted in centre of loom.   
leno threads are crossed for each weft thread inserted thereby locking the centre of the pick in place. this prevents excessive movement of the first inserted pick as the reed returns to back position. first and second weft thread is held in place by the warp threads crossing past each other as the reed moves forward to push them into place.  
â¢ fabric woven from twaron aramid yarn gives the optimum combination of ballistic performance vs. cost and weight  
â¢ ballistic fabric performance improvement by coating not worth increased weight penalty  
â¢ optimum fabric design achieved with style 05471 to give flexibility with ballistic performance  
â¢ weaving of 05471 at 170cm allowed ease of manufacture of final demonstrator by eliminating seams   
â¢ elimination of seams allows easier packing and deployment of the raptor shield  
â¢ 170cm width was defined as sufficient for height requirements of demonstrator  
  
coatings  
it has been proposed that by coating the fabric, the energy can be transferred into adjacent threads to those which have been immediately impacted through the coating. the coating acts as a barrier to prevent the freedom of thread movement by locking threads together so that the kinetic energy is spread over a larger area than just that surrounding the point of impact.  
the primary requirements for the coating to act as an energy dissipater are that the material selected should have:  
1. high ultimate tensile strength (uts) high tensile strength should reduce the tendency for the coating to rupture between adjacent threads which would prevent the energy being transferred from thread to thread.  
2. excellent elasticity. the elongation of the coating compound at the point of break should be as high to allow the energy to be dissipated over as large an area as possible   
laboratory testing at pd-its was carried out to determine the following characteristics of the coated fabric samples compared with the same tests on the uncoated 05471 material  
1. tensile strength warp and weft, kn/50mm. test method din/iso 4606  
2. coating add-on weight, g/mâ². test method din 53-854/12127  
3. trapezoidal tear strength, kn. test method astm 5733  
4. porosity at 2mbar pressure, litres/dmâ²/minute. using shirley porosity meter.   
from the results was concluded that:  
â¢ the add-on for silicone coating was much higher than for pu coating  
â¢ coating the fabric increased the stiffness  
â¢ the fabric stiffness increase was much higher for pu than for either silicone  
â¢ the stiffer coating gave increased tensile strength values  
â¢ the stiffest fabric had the lowest tear resistance  
â¢ the fabric porosity decreased when coated  
â¢ the higher coat weights of the silicones gave the greatest porosity decrease  
stiffness â measured using droop angle method. test method astm 5732.  
ballistic test series were performed to investigate the ballistic properties of coated fibre fabrics. ballistic testing was performed by firing of a handgun with different types of ammunition on the fibre fabric. the layers were tested in different configurations. in the first configuration the fibre fabric is loosely hanging. in the second configuration the layers are fixed on top and on bottom on a wooden frame.  
â¢ silicone type b, trade name âsilicone elastosil 3003/20â, is the best of the tested coatings. aramid fibre fabric coated with si b shows a continuously higher performance in reducing the energy of any tested bullet.  
â¢ the results for single side or double side coated material are close together â for deformation bullets (type i and ii) no significant difference can be spotted, fmjs are influenced more by double sided coating.  
â¢ for environmental protection a single side coating is enough. but to have the best efficiency it is better to keep weight down.  
  
4.1.3.3 ballistic tests  
fh-ict performed ballistic test series to investigate the protecting performance of the textiles provided, including the proposed âhandtuch-effektâ (âtowel effectâ) and the ballistic properties of different types of fibre fabrics. as a side effect an experimental setup was designed and evaluated, as well as the measuring methods most suitable for the characterisation of the experimental data. ballistic testing was performed by firing of a handgun with different types of ammunition at loosely hanging layers of fibre fabric. the projectiles are strongly damaged by the ballistic textiles; especially dyneema broadens strongly the head of fmjps.  
the provided ballistic packs were tested in various configurations, layers of 6 and 25 textile panels to study the energy reduction performance of the various textiles.  
the key findings of the ballistic tests were:  
â¢ no significant enhancement of performance due to angle variation  
â¢ no towel effect detectable  
â¢ set-up with close hanging layers, fixed on top and bottom is most goal-oriented  
â¢ pbo fibre fabric and polyurethane coated aramid have the lowest number of stopping layers for full metal jacket projectiles  
â¢ raw aramid fibre fabrics and silicone coated aramid fibre fabrics have the lowest number of stopping layers for deformation bullets  
â¢ still a problem: wide scattering between different ammunition types  
â¢ standardization shows:   
o pbo fibre fabric is highly effective with regard to its light weight! but is dismissed by the end user bka due to negative experiences with security vest containing pbo fibres (fast aging due to uv and moisture)  
o combined textiles are very effective and have a good strength-to-weight-ratio  
o favourite materials are aramid and the combination of wire reinforced aramid with dyneema (layer set-up: 3 a+w/20 dyneema/3 a+w)  
the protecting shield of the demonstrator  
the ballistic pack has been produced and supplied by valmiera glass in its final configuration, a fabric of 170cm height (style 05471, aramid 1680dtex warp and weft, ends per picks 12.6 x 12.6/cm, panama weave, weight 410g/m2). 170 cm was the final height due diverse factors like the limitation on the manufacturing (the manufacturing has achieved its large limit) and not to high total weight (each cm increased the total weight due the number of layers) as well.  
the fabric is fixed to the inflatable structure instead of mounted in a frame by lanco (see ballistic tests procedure described in previous deliverables).worst conditions have been used for the experiments, with a distance between the fabric and the shooter not exceeding 5 m and with an impact angle of 90â°, where the fibres receive the shot in the optimum geometry for the bullet to pass through them.   
various tests were performed improving the interaction of the various layers. the selected raptor demonstrator shows an excellent protective behaviour against all types of bullets and the blast and fragments from a hand grenade, even at short distances. the structure remains in its position, and the ballistic package (with a 10 cm sewing pattern) is able to stop the entirety of the fragments received from the hand grenade.  
  
4.1.3.4 gas generator development  
for a rapid erection and stable standing of the ballistic shield there had to be developed a suitable gas generator (gg) propellant composition to inflate reliably the protection kit or parts of its supporting structure.   
at fh-ict there are certain tools to conduct thermodynamic calculations to predict the theoretical gas output, combustion temperature and gas composition on basis of selected compositionâs components and stoichiometry. based on a wide range of experiences on the work field in scope, it was possible to preselect some promising raw materials. those raw materials are described below. the gas generator formulations, which are taken into consideration, are:  
â¢ fuel: 3-nitro-1,2,4-triazol (nitrotriazol)   
oxidizer: potassium perchlorate (kclo4); i  
or potassium perchlorate (kclo4) and basic copper nitrate (bcn)  
â¢ fuel: guanidine nitrate (guni)  
oxidizer: with potassium perchlorate (kclo4)  
or potassium perchlorate (kclo4) and basic copper nitrate (bcn)  
â¢ fuel: nitro guanidine (nigu)  
oxidizer: potassium perchlorate (kclo4)  
or potassium perchlorate (kclo4) and basic copper nitrate (bcn)  
summarized, the thermodynamical calculations showed the below listed results:  
the gas generator formulation containing 3-nitro-1,2, ...

# RAPTOR

Project Acronym: RAPTOR

programme & topic: FP7-SECURITY SEC-2007-1.2-02

Most frequent returning words in objectives:

* ('protection', 42)
* ('fabric', 33)
* ('security', 31)
* ('fibre', 22)
* ('fibres', 22)
* ('weight', 18)
* ('performance', 18)
* ('development', 17)
* ('layers', 17)
* ('project', 16)
* ('scenarios', 15)
* ('aramid', 15)
* ('fabrics', 15)
* ('hand', 13)
* ('structure', 13)
* ('demonstrator', 13)
* ('results', 13)
* ('yarns', 13)
* ('yarn', 13)
* ('generator', 12)
* ('textiles', 11)
* ('resistance', 11)
* ('threads', 11)
* ('weft', 11)

executive summary:  
raptor was a collaborative project funded by the european commission. the project involved 5 partners from 3 european countries, and had a total funding budget of around 2 million â¬. it was carried out over a period of 48 months from january 2010 to december 2013.  
the aim of the project was the development of innovative and integrated, mobile and rapid deployable, gas generator assisted inflatable structures for the ballistic protection of european civilians against security scenarios, such as crime and terroristic attacks. tailored solutions have been developed based on the scope (e.g. the prevention of, or the response to security scenarios by european security forces, such as protection of special persons or general security of events), including inflatable ballistic structures for the protection of:   
â¢ individuals  
â¢ groups of 2 â 5 persons (carried in trolley, back pack, etc.)  
â¢ general security of events (transported in car boot, by pick-up, truck, etc.)  
the concept was based on the fact, that not only heavy weight metal or light weight composites armouring, but also loose layers of aramid fibre fabrics can stop a bullet. the application area of the proposed protection device is strictly for civil application. scenarios of european security forces contain threats from hand held guns or improvised explosive devices (ied), which have much lower ballistic performance than military equipment e.g. machine gun or mortar grenade. however, a fast response should enable a rapid deployment which should by the inflation of the gases from gas generator as used in airbags for cars.  
the investigations included an outline of the threat scenarios which identified a list of situations where such a ballistic protection kit was urgently needed for improving security of individuals ending up with specifications. predominantly, 2-3 persons have to be protected against the attack by hand guns and hand grenade and enable a counter attack from this safe area.  
the ballistic protection was established by a multitude of textiles layers made out of aramide fibres. the fibre weaving applying various methods, treatment by lamination and their combination was optimized by measuring the energy reduction of various layers to achieve best resistance against the impact of the selected ammunition. the assumed effect of loose hanging fibres was disproved for this application ending with compacted textile layers. for the inflation of the ballistic package new approaches for the gas generator formulation and manufacturing techniques were needed. it combined pyrotechnic hot gas production with ablative cooling to provide cool gases for safely deploying the folded protecting shield stabilized by inflated tubular structure. finally, all components were combined in a demonstrator which was tested on a shooting range. the results showed that the ballistic shield deployed in a short time and withstood the demanded impact of bullets, fragments and blasts according to the specifications.   
the exploitation considers the innovative results of the developed components of the demonstrator, which will be also individually used. the basic project concept was concluded, has been summarized on the demonstrator and its functionality has been successfully tested. the demonstrator is planned to be further developed to be a protection kit available for future law enforcement by security forces. as the raptor demonstrator at the end of the project is a functional prototype rather than a ready to use prototype, the question of further financing/further project work was addressed. fundamentally, the possibilities will be considered and national research funds (e.g. in germany: bmbf = bundesministerium fã¼r bildung und forschung = federal ministry of education and research), from european funds (horizon 2020) or via a self-funded financing by demand of industrial partners as well. the dissemination of the results has been discussed and restricted issues respecting to the end user bka will be respected.  
  
project context and objectives:  
research on security is a main issue in europe to improve measures for protection of its inhabitants against manmade disasters or those induced by natural events. specifically, terrorism has strongly threatened people at all scales of dimensions in the recent years. the context of the project concerns the protection of individuals or small groups against direct attack by weapons.  
the overall objective of the project was the development of innovative and integrated, mobile and rapid deployable, gas generator assisted inflatable structures for the ballistic protection of european civilians against security scenarios, such as crime and terroristic attacks. depending on the scope tailored solutions have been developed, including inflatable ballistic structures for the protection of:   
â¢ individuals  
â¢ groups of 2 â 5 persons (carried in trolley, back pack, etc.)  
â¢ general security of events (transported in car boot, by pick up truck, etc.)  
  
the entire spectrum of personal protection gives rise to a large number of situations and sequences of actions which the relevant task forces of the bka deem to be critical. a clear distinction has been drawn between situations of daily importance and special scenarios like public appointments, pre-election campaigns, state visits or conferences, as well as travel movements of the protected person both at home and abroad. essentially, personal protection is influenced drastically and rendered more difficult by the following factors:  
â¢ lack of material protection on the way from one secure area to another by foot  
â¢ entry / exit of e.g. armoured vehicles  
â¢ event locations (indoors and outdoors), where a huge audience is present and not every member of the audience can be completely inspected  
â¢ spontaneous route changes of the protected person  
â¢ speakerâs desks in the immediate vicinity of uncontrolled spectator masses  
â¢ strict protocol regulations and / or limited resources  
â¢ lack of suitable resources and partly different security standards for personal protection measures abroad  
  
for this potential risks a solution has to be developed with respect to:  
â¢ providing a shelter in case of an attack  
â¢ attacking the aggressor from a covered position  
â¢ ensuring safe evacuation of the protected person  
based on the listed scenarios, specifications for the development of the security kit were defined and criteria for the demonstration of their effective performance derived. the most flexible and realistic appearance of the security kit is a trolley-like housing.   
the demands of the security kit were based on the requirements of ballistic protective vest level one. blast-impeding properties were required to minimize the effects of a fragmentation hand grenade, i.e. the side of the security kit facing the blast must neither be penetrated by primary nor secondary fragments that could endanger any person behind the wall. the demonstrator proved the protecting performance of the shelter. predominantly, 2-3 persons can to be protected against the attack by hand guns and hand grenade and enable a counter attack from this safe area.  
  
potential security scenarios included mobile security kits, such as:  
- briefcase/backpack for 1 person,  
- trolley/suitcase for 1-5 persons,  
- tent (e.g. on pick-up truck or in a soccer stadium under the floor) for bigger crowds  
- âred carpetâ tunnels  
- inflatable fences, and  
- inflatable curtains  
   
the application area of the proposed protection device is strictly for civil application. scenarios of european security forces contain threats from hand held guns or improvised explosive devices (ied), which have much lower ballistic performance than military equipment e.g. machine gun or mortar grenade.  
the objectives of the project were two fold â the development of the high performance flexible ballistic textile systems and the gas generation for inflation a stable structure to deploy the protection unit in short time.  
  
the objectives of the ballistic textile system development included:  
â¢ selection of high performance textile yarns to characterize their strengths and drawbacks according to the specified scenarios and ballistic calibres  
â¢ development of fabric weaving / coating technology to end up with a high performance fabric to enable high ballistic protection in combination with a light weight structure to realize fast deployment times like in airbag systems  
â¢ development and design of the ballistic protection structure concerning the requirements, e.g. light weight by combination of different fabrics and special coatings, number of fabric layers etc., according to the selected ballistic calibres  
â¢ development of gas tight support structures of tube like form to enable on the one hand fast deployment and on the other hand long holding time (> 3 hours) of the structure  
â¢ design and testing of different folding pattern concerning reliable structure deployment and small package volume as in airbag systems  
  
pyrotechnic gas generator compositions used in airbag systems provide a huge amount of non-toxic gas within milliseconds. the solid compositions consist of a fuel and an oxidizer and are usually pressed in pellet shape. the gas is generated by a combustion reaction.   
  
the objectives of the gas generator development were:  
â¢ selection of basic components of the pyrotechnic composition according to high gas yield above 400 dmâ³ per kg composition, non-toxic gas composition and low combustion temperature (below 2000 â°c)  
â¢ processing and shaping of compositions according to necessary gas production rate and safety parameters  
â¢ characterization of the combustion behaviour under pressure and the combustion temperature to select compositions with high combustion rates and low temperature  
â¢ design and development of the pellet shape to provide adjusted gas production enabling fast and reliable deployment of the fabric structure  
â¢ design and development of cooling agents reducing the gas temperature down to ambient conditions  
â¢ development and testing of the pyrotechnic gas generator combustion chamber in combination with the cooling agent to realize reaction times of the total system below 1 second  
the development of both basic systems was performed in parallel based on the elaborated specifications.  
objectives for protection were based on results of current approaches of individuals against fire of hand guns (soft-ballistics) which use clothing like helmets, vests or movable bullet-proof shields. there have been investigated effective ballistic fibres show high youngâs modulus, tenacity and elongation at break consist of p-aramides (twaronâ®, kevlarâ®) or umhwpe (dyneemaâ®, spectraâ®), an ultra-high molecular weight polyethylene. some typical products for military or automotive industry personal protection are laminates (in most cases plates or soft-shaped preforms) was took into account consisting of ballistic fabrics and polymeric binders or multiple-ply packs with several layers of textiles stitched together. standard textiles used for anti-ballistic applications were fabrics: twaronâ®, for example, offers a variety of p-aramide fabrics with different weaves like plain, basket or twill.  
  
in regard to official events, where outstanding persons have to be protected the concept of the mobile security kit follows the idea that a rapidly deployable unit leads to a surprising moment to the offender and that for a short period of time the single person or group to protect is hidden and counter measures by the security forces can come into action. objective of the deployable kit was to complete the protection of persons that are wearing protective clothing because of the fact that strikes on bullet-proof vests can cause serious injuries to the wearer like blunt traumata. in opposition to mobile protection kits like shields, inflatable tents or tunnels can protect persons from bullets coming from more than one direction and the position of the victim still remains invisible for the shooter. last but not least more than one person can be protected from gun shots. because of the possibility to deploy curtain-like structures with several layers of loose anti-ballistic fabrics hanging down in defined distances, a so called towel-effect has been verified  
with the additional specification of foldability - especially the ballistic textiles - havebeen constructed (stile of weave) and coated in that way that the single layers do not stick together and are resistant to creasing tendency. a second progress in textile modification beyond the state of the art was the development of textiles that meet the requirements of airbag application and that are stiff and airtight enough to maintain the specified shape desired time scales.   
finally, the gas generator for rapid inflation had to deploy the frame of the ballistic protecting device within its selected time scale. the security kit demonstrator was tested close to real conditions.  
  
project results:  
research on security in europe is a follow-up manmade disaster or those induced by natural events. it has to improved measures for protection of european inhabitants by innovative approaches. terrorisms evolved as threat strongly endangering people at all scales of dimensions in the past years. the project contributes to the need of protection of individuals or small groups against direct attack with weapons in exposed scenarios. it should develop a security kit which enabled a mobile and rapid deployable structure of a ballistic protection shield for european civilians against threat of a direct attack by weapons.   
  
4.1.3.1 scenarios and derived specification for the security kit  
the entire spectrum of personal protection gives rise to a large number of situations and sequences of actions which the relevant task forces of the bka deem to be critical. a clear distinction between situations of daily importance and special scenarios like public appointments, pre-election campaigns, state visits or conferences, as well as travel movements of the protected person both at home and abroad have been considered.   
to close lacks of security, firstly a trolley-like solution with a ballistic protection and fast deployment was considered to be a potent possibility as an additional personal security resource. with aid of such a ballistic protection device, the possibilities to provide a short-time shelter and to evacuate the protected person would be largely enhanced. furthermore, the aggressor can be fought off.   
the device developed in the raptor project has the potential to come to use in a multitude of situations to prevent terror and crime against european citizens and to increase their safety in many different threat scenarios.  
  
based on the above listed scenarios, specifications for the development of the security kit are defined and criteria for the demonstration of their effective performance derived. the most flexible and realistic appearance of the security kit is a trolley-like housing. therefore, the needed technical requirements which were derived analysing the treats are listed below:  
â¢ appearance: commercial travel trolley, divert attention  
â¢ transportable on airlines, motor vehicles and ocean liners  
â¢ total weight including ballistic package, support structure, gas generators and housing: maximum 15 kg  
â¢ manual triggering (one-handed operation)  
â¢ remote triggering with a max. reach of up to 10m  
â¢ ballistic protection in accordance to specifications   
â¢ protective space should be semi-circular  
â¢ protection kit height: 170 cm, width: 200 cm  
â¢ provides shelter for 2 â 3 persons  
â¢ durable, fixed position after unfolding   
â¢ possibility of shifting the deployed unit by carrying handles  
â¢ minimum time in fixed position: 30 seconds  
â¢ security package unfolds with the speed of an airbag  
â¢ insensitive to extreme temperature fluctuations (-35â°c to +85â°c) and shocks  
â¢ minimized danger during unfolding (brute force, burning, noise)  
the guideline has to be interpreted flexibly. for instance, the set-up of ballistic measurements complying with the directives leads to higher bullet velocities compared to ballistic measurements performed with handguns. for the project certain deviations should be accepted concerning the bullet velocities defined by the vpam guideline. special emphasis will be put on the kinetic energy on target. this energy should be as many as 500 joule (see above listed ballistic requirements). this value can be achieved with handguns as well. blast resistance should include stable protection against a hand grenade  
  
4.1.3.2 ballistic protection textiles  
the main components of the protection kit are the ballistic protection textiles. its development required the research, selection and modification of applicable fibres, yarns, fabric designs and fabric coatings for ballistic applications. a primary question in this context was about the protection level that best meets the threat scenario requirements.   
another important question was about which synthetic fibres could be applicable for ballistic protection. in several literature and product researches it was found that ideal antiballistic fibers for composite purpose have following profile (cunniff , auerbach, vetter and sikkema):  
â¢ high tensile and compressive modulus   
â¢ high tensile and compressive strength (in composite form),  
â¢ high damage tolerance,  
â¢ low specific weight,  
â¢ good adhesion to matrix materials (for structural composites only) and  
â¢ good temperature resistance.  
  
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chain molecules longitudinally orientated with paracrystalline structure and covalent bonds give  
â¢ high tensile strength and modulus  
â¢ high thermal stability and glass transition temp. (tg)   
â¢ high dimensional stability (low creep)   
â¢ non-brittle and high impact resistance  
â¢ good abrasion resistance  
â¢ high chemical resistance except strong mineral acids  
â¢ low dielectric constant  
â¢ poor resistance to uv radiation  
â¢ poor compressive resistance due to defibrillation   
â¢ absorbs up to 4,5 (5) % moisture by weight  
in the fibre selection process mehler uk stated that aramid fibre, either from dupont or teijin would be better than high molecular weight polyethylene because of the poor temperature resistance of dyneema, limited to a maximum of 70âºc. of the fibres from dupont, kevlar 29 would be his first choice and this is generally cheaper than kevlar 49 although good results had also been achieved with both fibre types. the twaron ct microfilament yarn from teijin introduced a few years ago was expected to give significant ballistic improvements however, this did not turn out to be the case and there is little to choose between the products from dupont and teijin.  
  
forms of fibres and yarns  
beside the question about what materials were used for fibres and further for fabrics one should give a short overview about different fibre forms and the use these forms.  
high performance fibres are generally used in one of four forms:  
â¢ staple fibre, 1 to 15cm long, usually spun into yarn  
â¢ chopped fibre, cut to short,specific length, often added to matrix  
â¢ monofilament , a single, large, continuous filament  
â¢ multifilament, extruded continuously with many filaments  
  
fibres were processed for use into one of four forms:   
â¢ yarn or roving for further use  
â¢ non-woven fabrics  
â¢ woven fabric  
â¢ knitted fabric  
yarn or roving for further use  
multifilament yarns are plied or twisted together and are used e.g. for sewing threads or ropes. rovings are â.long and narrow bundles of fibres.â (http://en.wikipedia.org), obtained either directly in primary manufacturing or by combining multiple threads together without any twist. they are used for filament winding processes for pipes, pressure cylinders or to make unidirectional reinforcements, either as fibre or woven fabrics.  
yarns for anti-ballistic applications  
an enhancement of the yarn strength can be achieved by increasing the twist .yarns for anti-ballistic fabrics are slightly twisted because they consist of endless filaments and not of staple fibres and only have to be hold together by twisting.   
yarns for blast resistance - auxetic yarns  
the use of auxetic yarns is being considered. fabric woven with this yarn type was tested as part of the eu-funded >>flybag project<< . this was a blast and fragmentation retaining device to protect aircraft from explosions in the cargo compartment. see below slides for explanation of the action of this type of yarn.  
  
weaving has a strong impact on the ballistic performance. it involved the following types with the listed results:  
â¢ weaving of auxetic yarn  
o liaising with stfi for information on fly-bag project, blast control  
o sourcing auxetic yarn from dr. hook of auxetix  
o setting up loom to weave auxetic yarns across a wire/glass warp   
â¢ weaving and supplying mock leno fabric samples to test âchain-mailâ effect  
o novel fabric to simulate effect of chain mail in ballistic tests  
o principle of âanisotropicâ fabric could be developed further  
â¢ weaving samples of fabric with zylon hm and dyneema sk65and sk90 weft yarn  
o sourcing samples of the test yarns  
o setting up loom to weave these high performance yarns not previously attempted   
â¢ weaving and supplying 1,000m of 05471/170cm for manufacture of final demonstrators  
o sourcing yarn and organising warp manufacture  
o overcoming problems experienced weaving panama construction at 170cm width  
  
for ballistic tests there were panels woven supplied to fraunhofer ict:  
â¢ 50 x 2m panels 05471 woven at sherborne  
â¢ 22 x 2m panels dyneema sk 65 weft  
â¢ 22 x 2m panels dyneema sk 90 weft  
â¢ 22 x 2m panels zylon hm weft  
â¢ approximately 150m warp yarn left on beam for weaving more of above fabrics or additional leno samples depending on results of ballistic tests.  
  
for the final demonstrator the following criteria were found using also the results of the next chapter:  
â¢ fabric type: style 05471, aramid 1680dtex warp and weft, ends x picks 12.6 x 12.6/cm, panama weave, weight 410g/m2   
â¢ fabric width: 170cm wide to remove requirement for seams in ballistic shield but giving sufficient height for protection  
â¢ production quantity: 1,000 linear metres woven will allow production of 10 to 12 demonstrators, each demonstrator requiring approximately 85lin.metres  
âpanamaâ weave similar to âplainâ weave but has two warp threads weaving in parallel together and two weft threads to be inserted side by side in each opening of warp threads.   
owing to increased width of 170cm, problems caused by first inserted thread being dragged out of position by âsuctionâ of reed moving rapidly backwards since warp threads are held open to allow second weft thread to be inserted. not a problem at narrower 107cm width   
problem overcome by use of leno-locking mechanism mounted in centre of loom.   
leno threads are crossed for each weft thread inserted thereby locking the centre of the pick in place. this prevents excessive movement of the first inserted pick as the reed returns to back position. first and second weft thread is held in place by the warp threads crossing past each other as the reed moves forward to push them into place.  
â¢ fabric woven from twaron aramid yarn gives the optimum combination of ballistic performance vs. cost and weight  
â¢ ballistic fabric performance improvement by coating not worth increased weight penalty  
â¢ optimum fabric design achieved with style 05471 to give flexibility with ballistic performance  
â¢ weaving of 05471 at 170cm allowed ease of manufacture of final demonstrator by eliminating seams   
â¢ elimination of seams allows easier packing and deployment of the raptor shield  
â¢ 170cm width was defined as sufficient for height requirements of demonstrator  
  
coatings  
it has been proposed that by coating the fabric, the energy can be transferred into adjacent threads to those which have been immediately impacted through the coating. the coating acts as a barrier to prevent the freedom of thread movement by locking threads together so that the kinetic energy is spread over a larger area than just that surrounding the point of impact.  
the primary requirements for the coating to act as an energy dissipater are that the material selected should have:  
1. high ultimate tensile strength (uts) high tensile strength should reduce the tendency for the coating to rupture between adjacent threads which would prevent the energy being transferred from thread to thread.  
2. excellent elasticity. the elongation of the coating compound at the point of break should be as high to allow the energy to be dissipated over as large an area as possible   
laboratory testing at pd-its was carried out to determine the following characteristics of the coated fabric samples compared with the same tests on the uncoated 05471 material  
1. tensile strength warp and weft, kn/50mm. test method din/iso 4606  
2. coating add-on weight, g/mâ². test method din 53-854/12127  
3. trapezoidal tear strength, kn. test method astm 5733  
4. porosity at 2mbar pressure, litres/dmâ²/minute. using shirley porosity meter.   
from the results was concluded that:  
â¢ the add-on for silicone coating was much higher than for pu coating  
â¢ coating the fabric increased the stiffness  
â¢ the fabric stiffness increase was much higher for pu than for either silicone  
â¢ the stiffer coating gave increased tensile strength values  
â¢ the stiffest fabric had the lowest tear resistance  
â¢ the fabric porosity decreased when coated  
â¢ the higher coat weights of the silicones gave the greatest porosity decrease  
stiffness â measured using droop angle method. test method astm 5732.  
ballistic test series were performed to investigate the ballistic properties of coated fibre fabrics. ballistic testing was performed by firing of a handgun with different types of ammunition on the fibre fabric. the layers were tested in different configurations. in the first configuration the fibre fabric is loosely hanging. in the second configuration the layers are fixed on top and on bottom on a wooden frame.  
â¢ silicone type b, trade name âsilicone elastosil 3003/20â, is the best of the tested coatings. aramid fibre fabric coated with si b shows a continuously higher performance in reducing the energy of any tested bullet.  
â¢ the results for single side or double side coated material are close together â for deformation bullets (type i and ii) no significant difference can be spotted, fmjs are influenced more by double sided coating.  
â¢ for environmental protection a single side coating is enough. but to have the best efficiency it is better to keep weight down.  
  
4.1.3.3 ballistic tests  
fh-ict performed ballistic test series to investigate the protecting performance of the textiles provided, including the proposed âhandtuch-effektâ (âtowel effectâ) and the ballistic properties of different types of fibre fabrics. as a side effect an experimental setup was designed and evaluated, as well as the measuring methods most suitable for the characterisation of the experimental data. ballistic testing was performed by firing of a handgun with different types of ammunition at loosely hanging layers of fibre fabric. the projectiles are strongly damaged by the ballistic textiles; especially dyneema broadens strongly the head of fmjps.  
the provided ballistic packs were tested in various configurations, layers of 6 and 25 textile panels to study the energy reduction performance of the various textiles.  
the key findings of the ballistic tests were:  
â¢ no significant enhancement of performance due to angle variation  
â¢ no towel effect detectable  
â¢ set-up with close hanging layers, fixed on top and bottom is most goal-oriented  
â¢ pbo fibre fabric and polyurethane coated aramid have the lowest number of stopping layers for full metal jacket projectiles  
â¢ raw aramid fibre fabrics and silicone coated aramid fibre fabrics have the lowest number of stopping layers for deformation bullets  
â¢ still a problem: wide scattering between different ammunition types  
â¢ standardization shows:   
o pbo fibre fabric is highly effective with regard to its light weight! but is dismissed by the end user bka due to negative experiences with security vest containing pbo fibres (fast aging due to uv and moisture)  
o combined textiles are very effective and have a good strength-to-weight-ratio  
o favourite materials are aramid and the combination of wire reinforced aramid with dyneema (layer set-up: 3 a+w/20 dyneema/3 a+w)  
the protecting shield of the demonstrator  
the ballistic pack has been produced and supplied by valmiera glass in its final configuration, a fabric of 170cm height (style 05471, aramid 1680dtex warp and weft, ends per picks 12.6 x 12.6/cm, panama weave, weight 410g/m2). 170 cm was the final height due diverse factors like the limitation on the manufacturing (the manufacturing has achieved its large limit) and not to high total weight (each cm increased the total weight due the number of layers) as well.  
the fabric is fixed to the inflatable structure instead of mounted in a frame by lanco (see ballistic tests procedure described in previous deliverables).worst conditions have been used for the experiments, with a distance between the fabric and the shooter not exceeding 5 m and with an impact angle of 90â°, where the fibres receive the shot in the optimum geometry for the bullet to pass through them.   
various tests were performed improving the interaction of the various layers. the selected raptor demonstrator shows an excellent protective behaviour against all types of bullets and the blast and fragments from a hand grenade, even at short distances. the structure remains in its position, and the ballistic package (with a 10 cm sewing pattern) is able to stop the entirety of the fragments received from the hand grenade.  
  
4.1.3.4 gas generator development  
for a rapid erection and stable standing of the ballistic shield there had to be developed a suitable gas generator (gg) propellant composition to inflate reliably the protection kit or parts of its supporting structure.   
at fh-ict there are certain tools to conduct thermodynamic calculations to predict the theoretical gas output, combustion temperature and gas composition on basis of selected compositionâs components and stoichiometry. based on a wide range of experiences on the work field in scope, it was possible to preselect some promising raw materials. those raw materials are described below. the gas generator formulations, which are taken into consideration, are:  
â¢ fuel: 3-nitro-1,2,4-triazol (nitrotriazol)   
oxidizer: potassium perchlorate (kclo4); i  
or potassium perchlorate (kclo4) and basic copper nitrate (bcn)  
â¢ fuel: guanidine nitrate (guni)  
oxidizer: with potassium perchlorate (kclo4)  
or potassium perchlorate (kclo4) and basic copper nitrate (bcn)  
â¢ fuel: nitro guanidine (nigu)  
oxidizer: potassium perchlorate (kclo4)  
or potassium perchlorate (kclo4) and basic copper nitrate (bcn)  
summarized, the thermodynamical calculations showed the below listed results:  
the gas generator formulation containing 3-nitro-1,2, ...

# Diginova

Project Acronym: Diginova

programme & topic: FP7-NMP NMP.2011.2.3-3

Most frequent returning words in objectives:

* ('digital', 94)
* ('fabrication', 68)
* ('manufacturing', 39)
* ('products', 37)
* ('technology', 30)
* ('materials', 27)
* ('printing', 25)
* ('applications', 24)
* ('technologies', 19)
* ('processes', 19)
* ('production', 16)
* ('material', 15)
* ('business', 15)
* ('industry', 13)
* ('development', 13)
* ('challenges', 13)
* ('inks', 13)
* ('textiles', 12)
* ('diginova', 11)
* ('drivers', 11)
* ('design', 11)
* ('cost', 11)
* ('value', 10)
* ('lead', 10)

executive summary:  
as the world is becoming ever more digital, decentralised and connected, the transition from analogue to digital technologies has a profound impact on many industries, markets, consumers and value chains. well known and clear examples of this transition can be found in the music industry, in photography, printing and communication.   
in common with many other industries, the manufacturing industry will also make the transition to the digital realm, and when it does, manufacturing will change beyond recognition. established (analogue) fabrication methods and technologies will be replaced by digital fabrication technologies and solutions. this is expected to lead to a revolution in the manufacturing industry that needs to be anticipated, understood and supported.  
â´we've had an industrial revolution.  
we've had a digital revolution.  
now is the time for a digital industrial revolution.â´  
  
although the potential of certain digital fabrication technologies (such as 3d printing/additive manufacturing, digital graphical printing and printed electronics) and associated applications is well recognized, so far there has been no coherent roadmap delineating how the benefits and the potential of the whole field and concept of digital fabrication should best be pursued. diginova aims to fill this gap by providing the first roadmap for digital fabrication in europe.   
  
digital fabrication is defined as a new industry in which computer controlled tools and processes transform digital designs directly into physical products.   
the key driving force and success factor appears to be the development of well matched combinations of advanced new material deposition processes and materials.  
  
the overall objective of the diginova project was to assess and promote the potential of digital fabrication for the future of manufacturing and materials research in europe. we have mapped the most promising application and material innovation domains, identified business drivers, key technology challenges and new business opportunities. we have also identified, connected to and involved a wide range of stakeholders across the value chain to assure wide acknowledgement and support. this has resulted in a roadmap and the underlying vision on digital fabrication that are intended to provide guidance for innovation in digital fabrication technologies, materials and applications and to clarify how digital fabrication is envisioned to lead to a radical paradigm shift in manufacturing. the roadmap also indicates how and why this paradigm shift is expected to open up opportunities for significant growth for the manufacturing industry and related material developments in europe.   
  
project context and objectives:  
over the past decades, the advance of mass manufacturing in europe has diminished and new production philosophies and approaches have emerged. during the 20th century, productivity and efficiency were the main driving forces, and production was based on analogue technology. in the middle of the century, the first computers appeared and process control and software impacted the manufacturing industry. by the end of the 20th century, digital technologies became increasingly important. computer controlled machining and robots became commonplace, leading to a reduced need for manual labour. the advent of a digital revolution became visible in the domains of engineering and manufacturing.  
we are convinced that successful innovation in digital fabrication can only result from a parallel, coherent and integrated development of functional materials, substrates and material deposition processes. while this may seem logical, it is not current practice. in most cases manufacturing processes are considered a given, and materials are designed around them, or at best âtuned to fitâ. it is very unfortunate to see that in this traditional approach, new and sometimes unique functional material properties are negatively affected or sometimes even lost.   
we believe that europe needs to rethink how it will stimulate cooperation in the development of new materials and new applications. the physical distances, i.e. lack of personal relationships and limited chances to share and create new concepts, hinder the further development of technology. in general, more active cooperation in europe is needed. today advances are occurring too often in isolated âsilosâ and in an almost disassociated way. fundamental to many digital fabrication technologies that were assessed by diginova, there is also a need to reconsider the design and production of many kinds of products. the future combination of printing new materials, substrate materials, electronics, and additive manufacturing technologies would contribute to the creation of many new products and could even repatriate some production activity from asia.  
wide adoption of digital fabrication techniques can certainly have profound implications, of which some are characterised and envisioned below:  
â¢ digital fabrication can be decentralised and it can strengthen local economies. as digital fabrication technology and processes evolve, the cost of digitally manufactured products will decrease. for certain applications digital fabrication may even evolve to the point where it can directly compete on cost with mass production. in addition, digital fabrication offers huge advantages and opportunities compared to mass manufacturing in terms of flexibility, customisation, personalisation and on-demand fulfilment. when cost barriers are sufficiently lowered, it will no longer be necessary to rely on centralised large factories from which mass produced products are shipped around the world. instead, products can be fabricated locally. products could essentially travel most of their journey as digitally stored data. design will be global; realisation will be local. this will greatly reduce or eliminate transportation costs and reduce carbon footprint. in shifting manufacturing (back) to local economies, europe could lead the way in reclaiming its manufacturing heritage and recapture a share of the production volumes that have been lost to asia in the past.  
  
â¢ digital fabrication is flexible. it allows for one machine or sequence of processes to fulfil many roles and reduces the use of space and resources. industrial mass-production generally requires a different factory for every type of product, but flexible digital fabrication allows one set of tools and processes to be used to make many devices. flexibility could ultimately make it worthwhile to invest in consumer fabrication tools; only industrialists invest in a tool that makes the same thing over and over again, but for certain applications a tool that can respond to one's personal needs could be a tool worth having even in your home.  
  
â¢ digital fabrication is customisable and interactive. the internet is revolutionizing media and information services because of the ease with which users can generate their own content. traditional media (tv, newspapers, radio etc.) are generally one-way channels that make it easy to be a consumer of information and difficult to become a producer. but with blogs, out-of-the-box websites, wikis and so forth, anyone can now broadcast information. even funding for realisation of new innovative ideas is now commonplace through crowd-funding initiatives (such as kickstarter). digital fabrication represents the same revolution whereby user-generated content can be brought to the manufacture of physical goods. with digital fabrication, consumers can specify, customise, design or ultimately even process materials into their own phones, their own computers, their own mp3 players or lighting fixtures. they will express their creativity in their products, rather than having to buy mass-produced ones. in fact, this is already beginning to happen, with large electronics manufacturers offering customisation on their web-sites, for example. in the next decade the current value chain with middle-men could be replaced by a simpler and short value chain, and the range of products made with new material functionality and combinations of functions could be extended. following this reasoning, the production chain is expected to evolve more and more from a âpushâ to a âpull/on-demandâ model.  
  
â¢ digital fabrication will ultimately lower costs. once local economies, communities or ultimately individuals have their own fabrication equipment for small runs, they can create a car, a mobile phone, agricultural equipment or whatever product at the cost of raw materials, limited transportation and local overhead. the standard industrial supply-chain inflates the price of manufactured goods. to buy a commercially mass manufactured computer, the price has to cover the costs of mining the material, shipping the material to, for example, china, running the machines, labour, marketing, more shipping, and mark-ups by several retailers. digital fabrication, by producing parts or products in one step on-demand, with no waste, directly from raw materials, empowers local manufacturing, and cuts out extra costs and reduces the cost to just energy plus information plus raw materials and maybe a limited number of very special parts. ultimately energy could be for free from the sun and information (designs) could become free from the internet, in which case the only remaining cost would be that of raw materials.  
  
â¢ digital fabrication contributes to a level playing field. means for communication, housing, medical equipment, agricultural equipment, electronics - let's assume that it would be a good thing to provide people in all countries access to these things. how are we to do it? one could say there are two ways: one is to manufacture the goods in developed and wealthy places and ship them, and the other is to manufacture them on-demand, on-site where they are needed, when they are needed, and in exactly the right quantities. of these two solutions, only the second one creates local economic stimulus, teaches technological skills and makes communities economically more self-sufficient.  
  
â¢ digital fabrication is evolving. the ultimate fruit of digital fabrication will be the molecular assembler that rearranges atoms and puts them in place at great speed to build almost anything, from nano-scale robots to ham sandwiches.  
  
vision for digital fabrication  
  
within the next 10-20 years, digital fabrication will increasingly transform the nature of global manufacturing, with an increasing influence on many aspects of our everyday lives. manufacturing will evolve towards a global distribution of digital design and specification files that will form the basis of local production. the economical advantage of large scale production will decrease, which makes smaller series production increasingly competitive and customised products affordable to an increasing number of consumers. the combined characteristics and possibilities of digital fabrication will generate new business models and new markets for new types of products and services. transformation to digital fabrication contributes to the decrease of resource consumption and resource-intensive production, targeting low-carbon and zero waste manufacturing. this paradigm shift in manufacturing opens up great opportunities for entirely new ways of production and material development in europe.  
  
the prime diginova objectives were:  
  
â¢ identify the most promising market opportunities for european manufacturing and related materials industry in ten and twenty years, including where a shift to digital fabrication will add the most value.  
â¢ identify the stakeholders, key players and opinion leaders in the defined key application fields of digital fabrication to understand their view of the market and related business models.   
â¢ determine a methodology to identify and catalogue the key technology challenges â both technological and business oriented- for the most promising market opportunites.  
â¢ create awareness and interest for digital fabrication and bring together partners from the value chain and other stakeholders to interact, receive input and create new networks.  
â¢ deliver a roadmap for digital fabrication drafted by the project partners together with all identified key actors. this will provide a meaningful framework and guideline for innovation for all actors in the innovation value chain.  
  
project results:  
digital fabrication will have an increasing impact on everyday life. the enabling of mass customization would allow customers to order fully bespoke products. within the diginova consortium we have made a shortlist of the nine most promising opportunities or applications for digital fabrication in terms of impact on manufacturing and life as a whole. these nine applications were identified through assessments and discussion within the consortium in conjunction with broad stakeholder involvement.   
most promising applications for digital fabrication  
  
1. digital graphical printing   
2. digital textiles  
3. functional end-use parts and products  
4. am objects with embedded printed intelligence  
5. oled lighting and displays  
6. smart windows  
7. printed sensors  
8. personalized diagnostic and drug delivery  
9. medical microfactories  
  
digital graphical printing  
the conversion from analogue to digital printing technologies is fuelling growth of the digital printing industry. digital printing enables on-demand production, zero waste, no need for stocks, high flexibility, fast-turnaround, small series, personalisation, mass customisation and very short distribution and supply chains. as one of the biggest industry sectors in the world, printing clearly offers a great opportunity, with inkjet emerging as the most promising digital printing technology. if we assume the analogue to digital conversion rate is about 50 % over the next 10 to 20 years, this results in a market potential of over $250 billon (â¬185 billon).   
digital textiles  
digital textiles consist basically of two slightly different applications: digital direct-to-fabric printing and digitally fabricated garments. digital textile printing technology supports versatility, quick delivery, short printing runs, cost effectiveness and especially the fast fashion market. next to adding decoration to textiles, an emerging field is to add other functions, like anti-bacterial and flame retardancy properties to textiles (smart textiles). although digital printing still only constitutes 2 % of the total market for printed textiles, it is assumed to be growing fast, at a compound annual growth rate of roughly 30 %.   
  
  
  
functional end-use parts and products  
the manufacturing of functional end-use products and parts constitute the core purpose of all manufacturing activity. the increased utilization of digital fabrication technologies has been driven mainly by the ability to efficiently manufacture a) geometrically complex components and products, which exhibit comparatively higher levels of performance or b) low quantities of products, down to a single unit. the current size of the european 3d digital fabrication industry (2012) can be approximated at $423 million (â¬309 million). we assume that the potential for revenue growth is very significant and will continue in the foreseeable future.  
additively manufactured objects with embedded printed intelligence  
innovative future products will integrate âreadyâassembledâ multifunctional devices and structures. integration of such functional structures will allow the incorporation of, for example, sensors, control logic, inâpart health monitoring, electronic interfaces, and internal energy distribution or communication devices. this will result in a new generation of extremely capable and high value products for many different applications. as an emerging application area, the impact of such products is difficult to forecast. it is clear however, that these products embody the combination of several disciplines of science. such combinations tend to lead to innovations that change the everyday lives of consumers.  
oled lighting and displays  
oled (organic light emitting diodes) technology can be applied to non-flat and bendable surfaces as an efficient, bright, lightweight and thin light source. oleds are used in lighting and display applications, such as smart phone screens, television screens and lighting panels. several advantages, like lightweight, potentially flexible structures and wider viewing angles, are driving this technology forward. currently, controlled thermal evaporation and spin coating are typically used for oled processing. if oleds were digitally fabricated with, for example inkjet technology, the two most important issues for oled production technology, i.e. price and scalability, could be overcome, while at the same time greatly enhancing freedom of design.  
smart windows  
smart windows can change light transmittance by applying an electrical current in response to an environmental signal such as sunlight or temperature sensed by a light/temperature sensor. when activated, the glass changes from transparent to translucent or tinted, blocking some or all wavelengths of light. they can help to save energy in highly glazed buildings by reducing cooling or heating loads and the demand for electric lighting. the use of digital fabrication for glass construction potentially allows smart windows to be produced at low-cost with small runs of customized products. different materials can be applied using the same types of equipment, and digital fabrication technologies can be envisioned opening up new design concepts to be readily produced for different applications in marketing, advertising and graphic design.  
printed sensors  
sensors are needed in various applications; to control industrial processes, monitor climate and environmental conditions or simplify the procedures of everyday life, to mention just a few. the specific input could be light, heat, motion, moisture, pressure, amongst other phenomena. the sensor output is generally a signal that is converted to human-readable information. printing enables manufacturing of cost effective large area sensor arrays on flexible substrates for various applications. however, fully printed sensors are not yet readily available on the market. digital fabrication is going to provide the capabilities required to produce printed sensors tailored to the specific application needs of the final consumer.  
personalised diagnostics & drug delivery  
personalised medicine refers to the tailoring of medical treatment and delivery of health care to the individual characteristics of each patient, aiming to accelerate diagnostics, increase effectiveness and efficiency of prescribed medications, and reduce the incidence of side effects. digital fabrication technologies, like inkjet printing, will allow the automation of diagnostics and support new opportunities to print highly complex multi polymorphism assays (such as âorgans on a chipâ), containing patient tissues with a range of markers for automated computational analysis and interpretation. printing technology could be used to generate a drug with patient specific dose and release rates as well as custom printed biosensor arrays. personalised medicine is in its infancy, and we estimate that the timescale for delivering huge value using this new technology will be over 20 years.  
medical microfactories  
the concept of a microfactory is usually linked to the miniaturisation of machining and assembly elements to allow for desktop-based fabrication of small devices. thus, medical microfactories can be understood as a standalone, dedicated manufacturing solution for a specific medical problem or condition. medical microfactories can be desktop size fabrication points of custom made medical devices such as dental aligners, prosthetic sockets, lower and upper limb orthotics or surgical instruments as well as stations supplying on-demand biocompatible skin sections that match the patientâs specific requirements. the key reason for the adoption of additive manufacturing within medical microfactories is the ability to make personalised geometries based on digital scanning. in addition, for a range of applications it is attractive to make highly porous structures with a range of micro and macro porosities. the emergence of fully functioning medical microfactories is at least a decade away from widespread adoption, but offers a big opportunity in future.   
  
  
  
  
  
  
  
  
  
  
  
  
  
business drivers   
the specification of an effective technology research agenda requires a thorough understanding of the motivators for the use of such technologies. in the diginova project such aspects have been analysed in the form of âbusiness driversâ. a business driver can be understood as a descriptive rationale supporting the vision of a manufacturing future based on digital fabrication. ideally, the identification of business drivers is backed up by empirical observations and expert accounts.  
the diginova project provided a unique opportunity to engage with a large group of over 120 technology users and domain experts to survey their views on the driving forces behind the spread of digital fabrication technology.   
the next paragraph presents the main drivers seen to motivate the adoption of digital fabrication technology in a generalised way. the information collected by the diginova project suggests that some business drivers act as common motivators for the adoption of all technology variants of digital fabrication. other business drivers have been identified to promote the diffusion of more distinct variants of the technology, such as ink jetting or additive manufacturing.  
business drivers for all digital fabrication technologies  
â¢ increasing design freedom, including feature size  
â¢ independence of economies of scale  
â¢ product customisation/ customer input/ personalisation  
â¢ reduction in lead times  
â¢ supply chain consolidation and decentralisation  
â¢ reduced raw material waste  
â¢ reduction of hazardous waste  
business drivers for digital printing technologies  
â¢ improved deposition accuracy  
â¢ greater material range  
â¢ ink/ toner substitutability  
â¢ substrate substitutability  
business drivers for additive manufacturing technologies  
â¢ part light weighting  
â¢ geometry/ topography/ thermal optimisation  
â¢ build material substitutability  
â¢ reduction in unit costs  
â¢ reduction of process energy consumption  
â¢ additional functionality/ multifunctionality/ material gradients  
  
  
the data collected throughout the diginova project suggest that there are three highly prominent motivators for the adoption of digital fabrication: the design freedom inherent to the approach, the capability of creating customised products and an independence of economies of scale. all three aspects stem from the toolless nature of digital fabrication, meaning that tooling is not employed and tooling expenses are not incurred. these drivers are widely believed to lead to innovative products which can be customised or differentiated and which can be manufactured efficiently in small production runs.  
reduction of lead times forms a further highly relevant business driver. the collected data suggest that it is a relevant factor in practically all applications based on additive manufacturing. in contrast, in applications based on ink jetting technology, the reduction of lead times appears to be a pronounced driver in graphical printing and industrial printing applications. it has been suggested that this is due to the fact that the implementation of additive manufacturing in industry is still in an early phase of technology diffusion and is facing incumbent conventional manufacturing technologies exhibiting longer lead times.  
beyond the technical aspects of the core processes, several aspects relating to supply chain innovation have been identified as driving forces behind digital fabrication. particularly in the area of printed products with paper and paper-like substrates as well as in the area of 3d fabricated consumer, defence and electronics applications, supply chain consolidation and decentralisation are identified as highly relevant business drivers. implementing digital fabrication in industries driven by these factors will open up new supply chain possibilities and distribution models for a variety of products.  
such changes in supply chains are also seen as opportunities to reduce the environmental impact of manufacturing. effectively, the creation of a distributed manufacturing structure based on digital fabrication may limit the need to transport intermediate and finished products over large distances. further environmental benefits may be realised through the characteristics of the processes themselves. as digital fabrication technologies are capable of building up components by incrementally adding material, significant waste streams associated with some subtractive conventional manufacturing processes, such as machining, can be avoided. especially where energy intensive raw materials are used, such as titanium, the elimination of raw material waste has been shown to lead to substantial energy savings.  
a further environmental aspect to consider in the performance of digitally fabricated products is the impact of such products during their useful life. as such products are likely to be differentiated for particular applications and exhibit high degrees of fitness for purpose, they are also likely to have a smaller environmental footprint during their use-phase. these benefits can be achieved by harnessing digital fabricationâs ability to create highly complex products for the manufacture of extremely efficient products, for example by light weighting methods in the aerospace industry.  
  
  
  
  
  
a survey of key technology challenges for major opportunities  
  
after looking at the general technology challenges associated with the materials and processes fundamental to digital fabrication, it is necessary to gain an understanding of the impact of these technology barriers on individual applications. it is thereby possible to obtain a more detailed picture of the avenues towards the desired economic and social benefits resulting from the diffusion of digital fabrication.  
by analysing the most promising applications together with their identified key technology challenges, it is possible to pinpoint individual concrete recommendations. such application focussed recommendations should be very helpful in the formulation of a future digital fabrication research agenda.  
  
digital graphical printing  
the use of digital fabrication in graphical print applications places a great emphasis on throughput, product quality, ink compatibility, and deposition accuracy. the following list contains the key technology challenges pertaining to this major opportunity, both in terms of materials as well as processes. in the view of diginova, it is critical that these challenges are addressed in future research.  
  
materials  
â¢ development of low cost materials and inks to become more competitive with traditional printing techniques.   
â¢ development of colour pigments or dyes for use in inks that exhibit excellent light fastness.   
â¢ reducing the size of colour pigment particles. development of colour pigment particles in inks with a size in the range of 10 to 50 nm holds significant promise.  
â¢ development of new inks with excellent performance in eco-aspects.   
â¢ finding alternatives for solvent based inks and uv curable inks (to improve the sustainability and safety of inks). promising inroads could be made with water based latex inks or water based uv curable inks.  
  
processes  
â¢ cost: formation of ultra-thin layers, matching the layer thickness of ink in offset printing (<1 micrometre).  
â¢ speed: development of inkjet printheads that enable higher speed through higher jetting frequencies and/or by using printhead arrays comprising of a higher number of nozzles. mems is a key enabling technology for new generations of printheads.  
â¢ print quality: high speed in-line image quality inspection systems for closed-loop measurement & control.  
â¢ compatibility of inks with very wide range of substrates.  
â¢ stable jetting of ultra-small droplets (1 pl) at very high frequencies.  
â¢ methods for high speed fixation and drying of inks.  
  
digital textiles  
technology challenges for digital textiles are to an extent similar to the ones that were identified for digital graphical printing, including lowering of ink costs, improvement of colour properties, matching of inks to a wide range of âreceiving mediaâ (in this case textiles), eco-aspects and achievement of highly reliable printing processes combining high speed, quality and reliability. for the realisation of digital textiles with added smart functionally the following challenges should be addressed by a programme of research:  
â¢ viability of embedding suitable electronic components. collaborative efforts need to be set up with the electronics industry. develop embedded functional but at the same time flexible and inconspicuous electronic components.  
â¢ continuous development and improvement of functional inks.  
for functional textiles in clothing the following challenges have been identified as pertinent:  
â¢ as clothing is worn by humans all materials must be completely safe.   
â¢ achieve haptic and visual properties comparable to traditional garments or at least acceptable.  
â¢ garments must be sufficiently uv insensitive and wear resistant.   
â¢ an essential criterion for the materials is that they must be cheap enough to enable an attractive value proposition.  
for fully 3d printed textiles/garments, the following challenge is seen as critical:  
â¢ processes to completely (3d) print textile garments and the associated required materials need further research and development to ensure that fully printed garments are robust, flexible and capable of producing properties that are comparable to traditional garments.   
  
functional end-use parts and products  
the truly routine application of digital fabrication in manufacturing applications is facing major challenges at the current state of technology. these range from process fundamentals, process economics, industrial implementation, consistent quality and control as well as product data handling and specialized training. these aspects are especially relevant as the technology will need to outperform established conventional manufacturing processes in many cases.  
the following specific challenges towards the mainstream implementation of digital fabrication for the manufacture of functional end-use products should be addressed by a programme of research:  
â¢ increased deposition speed and system productivity.  
â¢ improved core components of digital fabrication system, including new approaches to scanning or sources of energy and the transition from point processing to line-processing to plane-processing to volume-processing.  
â¢ reductions in manufacturing cost.  
â¢ improvements in productivity, repeatability and reliability.  
â¢ reduction of process-borne waste streams on some platforms.  
â¢ lacking suitability of existing design tools and product data handling.  
â¢ establishment of a framework of standards and regulation, including product liability.  
â¢ lacking education and training opportunities.  
â¢ development of novel materials, matching or exceeding the properties of materials used in conventional processes.  
  
  
am objects with embedded printed intelligence  
the multi-layer, multi-material deposition of functionally integrated devices is a challenging opportunity for digital fabrication. this is due to the fact that digitally fabricated embedded functional structures are mostly manufactured in hybrid manner, combining various additive and conventional technologies. modular production configurations featuring elements of digital fabrication and conventional processes have been introduced to meet this challenge.   
  
the diginova project has identified the following list of main challenges towards the realisation of novel products with embedded printed intelligence:  
â¢ combination of multiple materials into a single integrated product.  
â¢ improvement in the reliability of printhead architectures and operation systems.  
â¢ systems for the control and avoidance of deposition errors, including error prevention prediction, detection and correction.  
â¢ requirement for specialized design software for multi-material and integrated 3d products.  
â¢ the currently available palette of build materials for functionalised embedded structures is severely lacking. require ...

# Diaspora

Project Acronym: Diaspora

programme & topic: FP7-PEOPLE FP7-PEOPLE-2011-IEF

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* ('loom', 9)
* ('weights', 6)
* ('cyprus', 4)
* ('sites', 4)
* ('research', 4)
* ('centre', 4)
* ('material', 3)
* ('textiles', 3)
* ('ancient', 3)
* ('world', 3)
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* ('lejre', 3)
* ('heritage', 3)
* ('west', 2)
* ('technologies', 2)
* ('identities', 2)
* ('south', 2)
* ('italy', 2)
* ('tool', 2)
* ('areas', 2)
* ('focus', 2)
* ('segesta', 2)

west and east:  
textile technologies and identities in the 1st millennium b.c. south italy and cyprus  
fp7-people-2011-ief proposal no 298974  
  
final report  
  
the aim of the project has been to explore textile tool technologies, identities and the socio-cultural dynamics in settler and indigenous cultural contexts in south italy and cyprus in the iron age/archaic period, roughly the 8thâ5th centuries bce. these two geographical areas were both subject to large-scale greek and, as regards cyprus and sicily, also to phoenician influx. as the project progressed the emphasis was redirected to focus on the archaeological sites of monte iato, segesta and mozia in west sicily and san vito dei normanni and cavallino in apulia as these provided abundant material. during the project more than a thousand loom weights were documented. a highlight of the documentation was the discovery at segesta of an inscribed loom weight with an important inscription to be published in the context of an interdisciplinary effort. documentation also included select material from the site of idalion, cyprus and future research will compare the similarities and dissimilarities involved.  
  
textiles in the ancient world, as in todayâs world, were of utmost importance for clothing, furnishings, for sacks, as storage and carrying devices, and for sailcloth. the socio-economic impact of the trade in textiles and the use in gift exchange in the ancient world was profound. few textiles are preserved in the archaeological record since optimal environmental conditions are the prerequisite for such preservation. nevertheless, the recovered tools used to produce them, can provide a wealth of information. the project has thus looked at the technological parameters of textile tools with a focus on a particular type of textile tool, the loom weight, used on the warp-weighted loom to provide the correct tension for optimal weaving.   
  
the project has profited from the methodology in experimental archaeology developed by scholars at the danish national research foundationâs centre for textile research (ctr), at the university of copenhagen, in collaboration with craftspeople at the sagnlandet-land of legends, lejre archaeological experimental centre in denmark. the methodology developed there has thus been applied to the loom weights under examination. from the textile implements used such as loom weights and spindle whorls, it is now possible to calculate within a range the type of fabrics that were produced at given archaeological sites. replicas of select textile implements were manufactured by the fellow at the lejre centre and tested (fig. 1). one important result of the project is the conclusion that fine and very fine textile fabrics were manufactured at the sites studied.   
  
a novel theoretical approach used in the project was the use of phenomenology as an analytical framework applied to this kind of archaeological material. it is an approach that positions the researcher as an active participant in an analytical process in which artefacts are seen as expressions of past âlife-worldsâ transcending the user and maker behind them. the major result of the analysis of the examined loom weights at the chosen sites is that the loom weights, as cultural agents, are definite identity markers. as such, they are the expression of local traditions, rather than ethnically defined as greek/phoenician or indigenous. these artefacts are hybrids of a kind, mirroring the cultural settings they were a part of. intriguingly, the loom weights despite portraying similar technical parameters portray the essence of what is unique at each site.  
  
the importance of cultural heritage has also been an important component throughout the project. contacts with weaving co-operatives in the regions of calabria and apulia have furthered the fellowâs knowledge in the multi-faceted weaving traditions in these areas, resulting in the dissemination at an international workshop of a little known plant fibre, spanish broom, spartium junceum, traditionally used in textile manufacture in calabria. the fellow also attended an international conference organized by ctr, on cultural heritage in amman, jordan, conducive to future collaborative efforts within the field.  
  
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# SUSTA-SMART

Project Acronym: SUSTA-SMART

programme & topic: FP7-NMP NMP.2012.4.0-2

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* ('susta-smart', 19)
* ('textiles', 14)
* ('project', 13)
* ('projects', 12)
* ('smart', 11)
* ('protective', 10)
* ('products', 8)
* ('textile', 6)
* ('construction', 5)
* ('issues', 5)
* ('research', 5)
* ('equipment', 5)
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* ('relevant', 5)
* ('interaction', 4)
* ('impact', 4)
* ('group', 4)
* ('partners', 4)
* ('document', 4)
* ('market', 3)
* ('consumer', 3)
* ('goods', 3)

project context and objectives:  
goal  
a variety of smart textile products with a high market potential in the area of smart ppe, construction materials and consumer goods have been developed with european funding. as all these products have to comply with legal regulations, standardisation issues are crucial for exploitation and commercialization. this fact has been and is not always taken into account during the product development in the eu projects, usually due to lack of knowledge in the consortium on standardisation issues. here the susta-smart project aimed at developing solutions for reinforcing the link between research and standardisation in order to boost the market uptake of smart textiles.  
focus domains  
given the wide range of potential applications for smart textiles, the efforts were restricted to the integration of electronics and focussing on three domains:  
1. personal protective equipment (ppe)  
2. construction and infrastructure  
3. consumer goods  
focus projects  
the aim of susta-smart was tot support standardisation needs encountered in r&d and innovation projects involving smart textiles. starting from representative eu fp7 nmp projects  
1. safe@sea - advanced personal protective clothing  
2. polytect - smart textiles for reinforcing and monitoring infrastructure  
3. dephotex - flexible photovoltaic textile  
susta-smart aimed at demonstrating the standardisation needs encountered during research and development.  
approach  
susta-smart aimed at increasing the interaction between research and standardisation by a systematic three step approach:  
1. identify the relevant standardisation actors and map issues which emerged from european research projects.  
2. synthesize and prioritise needs to draw up a standardisation roadmap.  
3. delivery of standardisation input documents and presenting them to relevant standardisation committees.  
impact  
backed by external key players such as companies and standardisation actors susta-smart gathered sufficient critical mass to reach its ambitious goals at european and international level.  
  
project results:  
several european fp6/fp7 smart textiles projects resulted in a variety of high market potential developments. representative nmp projects are safe@seaâadvanced personal protective clothing; polytectâsmart textile materials for reinforcing and monitoring infrastructure and dephotexâflexible photovoltaic textiles. standardisation is considered a key issue for further exploitation and commercialisation of smart textiles, especially for ppe and construction products as it supports legal provision in those areas.  
susta-smart started from the standardisation needs encountered in these projects, which had each at least one susta-smart partner involved, as well as those from a carefully selected group of other fp6/fp7 projects. given the wide range of potential applications, the efforts were restricted to three focus domains: personal protective equipment (ppe), construction products and consumer goods.  
susta-smart followed a systematic three step approach to forward standardisation:  
- mapping both the relevant standardisation actors and the standardisation issues of the fp6/fp7 projects. for the latter, a standardisation strategy audit procedure was worked out.  
- synthesising and prioritising of the needs, based on a broad consensus, leading to a standardisation roadmap.  
- compilation of dedicated standardisation input documents (including new work item proposals) and presenting them to relevant standardisation committees. here there was a strong cooperation with cen tc 248 wg31 â smart textiles, the convenor of which is also the coordinator of susta-smart and cen-clc bt wg 8 â protective textiles and personal protective clothing and equipment, the chair and secretary of this wg both also being susta-smart partners.   
additionally guidance documents were developed during the susta-smart project. the first guidance document is written for writers of research projects on how to integrate standardisation issues in their work plan. the second document is a draft guidance document for certification and conformity assessment (with eu legislation) of complex products. this type of document was found to be important and necessary for smart textile products in the ppe and construction products field.  
  
potential impact:  
in the course of the project, the work of the susta-smart project, in particular the interaction with relevant standardisation committees has already had an impact on their working. here two examples in particular have to be named.   
1) cen/tc 248 wg 31 smart textiles  
with k. eufinger from centexbel being both the coordinator of susta-smart and the convenor (chair) of this wg there has been a strong interaction between the project and the wg. there has been feedback on the projects of the working group to the project and regular updates from the project to the wg. susta-smart partner imec is also actively participating the development of one of the current standards on conductive textile tracks ((wi=00248533 textiles and textile products - electrically conductive textiles - determination of the electrical resistance of textile-based tracks)  
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this working group was established november 2012 under cen and cenelec bt to prepare the answer to the programming mandate m/509 en protective textiles and personal protective clothing and equipment. the report was submitted to the european commission in february 2014. susta-smart partners h. vanhoutte, esf is and k. eufinger, centexbel are respectively chair and secretary of this wg. additionally susta-smart partners euratex and fesi were following up this wg. as a result there was a strong interaction between the susta-smart project and this wg with regular feedback on the progress and final results of the working group to the project and vice versa.  
the european commission has already responded to this report and during a public inquiry for a mandate planned for 2015 also input from the susta-smart project could be given, which have the potential to be included in the mandate.   
since there is a strong involvement of susta-smart partners in other standardisation bodies, the impact of the project is being realised here, too.  
list of websites:  
www.susta-smart.eu

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the aim of susta-smart was tot support standardisation needs encountered in r&d and innovation projects involving smart textiles. starting from representative eu fp7 nmp projects  
1. safe@sea - advanced personal protective clothing  
2. polytect - smart textiles for reinforcing and monitoring infrastructure  
3. dephotex - flexible photovoltaic textile  
susta-smart aimed at demonstrating the standardisation needs encountered during research and development.  
approach  
susta-smart aimed at increasing the interaction between research and standardisation by a systematic three step approach:  
1. identify the relevant standardisation actors and map issues which emerged from european research projects.  
2. synthesize and prioritise needs to draw up a standardisation roadmap.  
3. delivery of standardisation input documents and presenting them to relevant standardisation committees.  
impact  
backed by external key players such as companies and standardisation actors susta-smart gathered sufficient critical mass to reach its ambitious goals at european and international level.  
  
project results:  
several european fp6/fp7 smart textiles projects resulted in a variety of high market potential developments. representative nmp projects are safe@seaâadvanced personal protective clothing; polytectâsmart textile materials for reinforcing and monitoring infrastructure and dephotexâflexible photovoltaic textiles. standardisation is considered a key issue for further exploitation and commercialisation of smart textiles, especially for ppe and construction products as it supports legal provision in those areas.  
susta-smart started from the standardisation needs encountered in these projects, which had each at least one susta-smart partner involved, as well as those from a carefully selected group of other fp6/fp7 projects. given the wide range of potential applications, the efforts were restricted to three focus domains: personal protective equipment (ppe), construction products and consumer goods.  
susta-smart followed a systematic three step approach to forward standardisation:  
- mapping both the relevant standardisation actors and the standardisation issues of the fp6/fp7 projects. for the latter, a standardisation strategy audit procedure was worked out.  
- synthesising and prioritising of the needs, based on a broad consensus, leading to a standardisation roadmap.  
- compilation of dedicated standardisation input documents (including new work item proposals) and presenting them to relevant standardisation committees. here there was a strong cooperation with cen tc 248 wg31 â smart textiles, the convenor of which is also the coordinator of susta-smart and cen-clc bt wg 8 â protective textiles and personal protective clothing and equipment, the chair and secretary of this wg both also being susta-smart partners.   
additionally guidance documents were developed during the susta-smart project. the first guidance document is written for writers of research projects on how to integrate standardisation issues in their work plan. the second document is a draft guidance document for certification and conformity assessment (with eu legislation) of complex products. this type of document was found to be important and necessary for smart textile products in the ppe and construction products field.  
  
potential impact:  
in the course of the project, the work of the susta-smart project, in particular the interaction with relevant standardisation committees has already had an impact on their working. here two examples in particular have to be named.   
1) cen/tc 248 wg 31 smart textiles  
with k. eufinger from centexbel being both the coordinator of susta-smart and the convenor (chair) of this wg there has been a strong interaction between the project and the wg. there has been feedback on the projects of the working group to the project and regular updates from the project to the wg. susta-smart partner imec is also actively participating the development of one of the current standards on conductive textile tracks ((wi=00248533 textiles and textile products - electrically conductive textiles - determination of the electrical resistance of textile-based tracks)  
2) cen-clc bt wg 8 p protective textiles and personal protective clothing and equipment  
this working group was established november 2012 under cen and cenelec bt to prepare the answer to the programming mandate m/509 en protective textiles and personal protective clothing and equipment. the report was submitted to the european commission in february 2014. susta-smart partners h. vanhoutte, esf is and k. eufinger, centexbel are respectively chair and secretary of this wg. additionally susta-smart partners euratex and fesi were following up this wg. as a result there was a strong interaction between the susta-smart project and this wg with regular feedback on the progress and final results of the working group to the project and vice versa.  
the european commission has already responded to this report and during a public inquiry for a mandate planned for 2015 also input from the susta-smart project could be given, which have the potential to be included in the mandate.   
since there is a strong involvement of susta-smart partners in other standardisation bodies, the impact of the project is being realised here, too.  
list of websites:  
www.susta-smart.eu

# SAFEPROTEX

Project Acronym: SAFEPROTEX

programme & topic: FP7-NMP NMP-2008-4.0-9

Most frequent returning words in objectives:

* ('properties', 54)
* ('protective', 30)
* ('project', 27)
* ('fabrics', 25)
* ('protection', 23)
* ('development', 20)
* ('heat', 19)
* ('garments', 18)
* ('developed', 16)
* ('yarns', 16)
* ('comfort', 15)
* ('fibers', 15)
* ('temperature', 15)
* ('application', 13)
* ('safeprotex', 12)
* ('order', 12)
* ('surface', 12)
* ('thermal', 12)
* ('textiles', 12)
* ('polymers', 12)
* ('conditions', 11)
* ('operations', 11)
* ('materials', 11)
* ('self-cleaning', 11)

executive summary:  
   
the concept of safeprotex concerns the development of protective uniforms, incorporating multiple protective properties and designated for rescue teams operating under complex risky conditions. in particular, three representative risky operations were considered, namely:  
  
ï­emergency operations under extreme weather conditions (floods, hail, etc),  
ï­operations under the risk of wild land fires, and  
ï­operations of first aid medical personnel, potentially exposed to any risk.  
  
the key scope of the project was to address the main limitations of existing protective garments and, in this context, to develop uniforms exhibiting: (a) protection against multiple hazards, (b) physiological comfort, ergonomic design and enhanced mechanical parameters, and (c) extended service life.  
having identified the protective properties required in each operation considered, additional user requirements were defined through close collaboration with end-users. market trends and relevant legislation were also considered in order to set-up the specifications of the garments to be developed.   
  
thereafter, to achieve its objectives, the project followed a bottom-up approach, starting at the nano-level and encompassing the entire value chain of the textile industry. in fact, project partners developed new additives and functionalizing agents, novel fibers and textile structures as well as multi-functionalizing surface treatments. the new developments include the development of thermo-regulating bi-component fibers incorporating non encapsulated phase change materials, of thermochromic polymeric sheets that act as high temperature alert systems when incorporated in the ppe, of 3d knitted liners, providing thermal insulation in low environmental temperatures, and of sol-gel surface treatments providing super-hydrophobicity, self-cleaning and antimicrobial properties, without deteriorating the handle and moisture management properties of the textile. after selection of the most appropriate materials and technologies that can be combined together, three prototype protective garments were produced, one for each type of operation, combining the following protective properties:  
  
ï­prototype 1 (extreme weather conditions): water impermeability, thermal insulation, super-hydrophobicity, self-cleaning and antimicrobial properties, high abrasion resistance in specific parts and thermo-regulation.  
ï­prototype 2 (wild land fires): fr properties, super-hydrophobicity, self-cleaning and antimicrobial properties, uv protection, protection against heat/cooling effect, high temperature alert and thermo-regulation.  
ï­prototype 3 (first aid medical personnel): super-hydrophobicity, self-cleaning, antimicrobial properties, fr, antistatic properties and thermo-regulation.  
  
the design of the garments varied depending on the application and usersâ requirements (e.g. an overall was selected for prototype 1 and two-pieces garments for prototypes 2 and 3). life cycle analysis proved the environmental benefit of the garments developed in safeprotex. the preliminary cost analysis indicated that the total cost of each developed product is competitive enough to create strong market opportunities also taking into account the lower maintenance requirements, as well as the extended duration of use. in addition to the objective lab testing and examination of the new textiles and garments, the prototypes were evaluated by the end users with very positive results and constructive comments for further improvement. three partners have already expressed their strong interest and commitment of exploiting the outcomes of the project by introducing new protective garments in the market.  
project context and objectives:  
the concept of the project concerns the development of protective uniforms, incorporating multiple protective properties and designated for rescue teams under complex risky conditions met in various types of everyday emergency operations.  
  
technological developments and climatic changes have both led to a large increase in the hazards to which humans are exposed. since a garment or a uniform constitutes the safety barrier between the wearer and the source of potential injury, its characteristics will determine the degree of injury suffered in case of an accident or an emergency operation. the steady evolution of health &amp; safety requirements to respond to new types of risks makes it necessary to develop new innovative products and to ensure their reliability. indeed, the range of hazards and the means of combating them continue to grow and become ever more complex. emergency teams are trained to face operations varying from small scale or wild land fires, extreme weather incidents and other complicated situations. even in a given emergency operation, rescue teams are exposed to a variety of risks.   
  
the idea that constituted the basis of the proposed project was to create innovative solutions to address the main limitations of existing protective garments designated for rescue teams and emergency operators. thus, the key scope of safeprotex was to develop uniforms exhibiting the following characteristics:  
  
ï§ protection against multiple hazards   
ï§ physiological comfort and enhanced mechanical parameters  
ï§ extended service life compared to existing protective clothing   
  
in the frame of safeprotex, three representative risky operations were considered and the corresponding protective uniforms were developed as prototypes. more specifically, the project addressed the following operations:  
  
â¢ emergency operations under extreme weather conditions (floods, hail, etc)  
â¢ operations under the risk of wild land fires  
â¢ first aid medical personnel potentially exposed to any type of risk  
  
the protective properties required in each of these cases are:  
  
â¢ for case 1 (emergency operations under extreme weather conditions): hydrophobicity, water impermeability, thermo-insulation, antibacterial properties, weather &amp; wind resistance.  
â¢ for case 2 (operations under the risk of wild land fires): fr and heat protection, uv protection, cooling effect, high temperature alert  
â¢ for case 3 (first aid medical personnel): antibacterial properties, thermo-regulation, antistatic properties, fr and heat protection, uv protection  
  
moreover, some properties are required in all three cases, including self-cleaning properties, enhanced mechanical parameters and comfort properties (heat and moisture transfer, thermoregulation and mechanical comfort).  
  
more specifically, the project focused in the following aspects of protective clothing development:  
  
1. protection against multiple hazards   
  
as indicated above, the hazards that rescue teams are exposed to, particularly in emergency operations, are at the same time multiple and complex. the main protective properties required and targeted within safeprotex are outlined below:   
  
protection against wetting and water permeation  
protection against extreme environment temperatures  
protection against microbial contamination  
protection against fire and associated heat  
protection against uv radiation  
protection against static electricity   
  
since, several different hazards may be simultaneously encountered in a specific situation, the new trend in research and development of protective textiles lies in the combination of various functionalities in order to obtain multi-protective garments. in this context, the project contemplated the exploitation of novel or advanced technologies to reach each of the above functionalities and then to combine the targeted properties. functionalization was achieved through bulk modification of the fibers and surface treatments of the developed textiles. the variety of options available to the consortium regarding both the functionalizing materials and their application technology ensured that multiple protective properties could be simultaneously achieved.  
  
2. physiological comfort, mechanical parameters and ergonomics  
  
personal protective clothing, in the first place, must provide adequate protection against occupational hazards and mechanically inflicted injuries. protective garments should be strong enough and present good mechanical properties, like tear resistance, tensile strength, breaking force and elongation.   
  
moreover, ppe possess a physiological function, protecting the wearer against heat or cold stress and yielding an at least satisfactory wear comfort. protective clothing results in a micro-environment between itself and the body (thermoregulation). workers are then exposed to a heat or cold stress greater or lower than the ambient environment alone, which is a reflection of micro-environment, metabolic rate and time. adjustments to the ambient environment to account for the micro-environment must be formulated as a means to predict heat or cold strain for safety and productivity purposes.   
  
garments without such a physiological function do not only affect our well-being, but with man working they impede his physical and mental performance and they can even be health-damaging.   
  
air permeability is especially important for comfort of outwear and protective textile products: it deals with material behaviour when exposed to still or slowly moving air and also indicates the wind resistance. air permeability is set by standards en 342 &amp; 14058 as 3 levels, depending on comfort feeling it offers.   
  
finally, clothing with good breathability gives workers the opportunity of doing their work without feeling suffocating. this involves thermal resistance (body heat) and water vapour resistance (perspiration) revealed through the cloth and permits the human to feel comfortable when doing his job.  
  
however, textiles functionalization is usually accomplished at the expense of comfort and/or mechanical parameters. indeed, the application of common coatings as well as the incorporation of active agents, such as flame retardants (frs), in textile fibres in the required amounts to bring the desired effects, is generally accompanied by a decrease in mechanical performance and comfort parameters, i.e. breathability, moisture management, handle, etc. therefore, improved ergonomic and comfort properties are becoming essential in order to achieve an optimal balance between protection and performance.  
  
safeprotex exploited recent advances in nanotechnology to avoid these detrimental effects of textiles functionalization. for example, skin sensorial wear comfort (i.e. smoothness and softness) can be retained after the surface application of active nano-materials, not affecting the basic properties of the fabric. the proposed approach to thermo-physiological wear comfort involved the application of phase-change materials (pcms) through innovative processes. finally, the ergonomic wear comfort, i.e. the fit of the clothing and freedom of movements, was considered through the ergonomic design based on user requirements.   
  
3. extension of the service-life of protective garments  
  
an important issue that was addressed in the project is the durability of protective functions. in fact, a common drawback of protective textiles is related to the deterioration of functional properties after use and consecutive washings. the solution proposed in the project to ensure optimal performance over the whole service-life of protective garments was their self-cleaning functionalization or the induction of water and oil repellent properties, in order to minimize washing requirements. in the same context, the maintenance of high breathability may limit contamination coming from the wearer.   
  
4. user &amp; environment friendliness  
  
an important issue when developing protective garments is the environmental aspect of the involved materials and processes. any materials and processes that are harmful to the environment (and humans) should be avoided in order to comply with current legislation and directives (e.g. reach regulation, eco-labels, etc). therefore, such criteria were taken into consideration when selecting fibrous substrates, active agents and treatment application processes.  
  
the distinct scientific and technological (s&amp;t) objectives of the project included:  
  
ï§ the development of new functionalizing nanoadditives.  
ï§ the appropriate modification of nanoparticles (clays and carbon nanotubes), when necessary, and their subsequent dispersion in polymeric matrices for the development of new polymer-based nanocomposites.  
ï§ the development of nanocomposite or bi-component fibers exhibiting superior mechanical performance, flame retardancy, thermal stability, antistatic properties and/or thermo-regulating effects, through the incorporation of layered silicates (clays), carbon nanotubes (cnts), chromic dyes and phase-change materials (pcms).   
ï§ the design and development of new fabrics through the incorporation of novel/functional fibers and components reacting to external impulses.   
ï§ the exploitation of alternative technologies including sol-gel, microencapsulation, finishing, plasma, etc, for the pre-activation and the surface functionalization of textiles.   
ï§ the assessment of any synergistic or antagonistic effects of various textiles treatments.  
ï§ the ergonomic design and development of optimized garment constructions.   
ï§ the realization and evaluation of prototypes corresponding to the hazardous situations (cases) presented in table 1. it should be emphasized, however, that the technological innovations contemplated within safeprotex could also serve for the development of alternative protective equipment as well as in a variety of different applications. the specific prototypes are only representative cases that may prove the efficacy of the projectâs achievements.  
project results:  
technical achievements regarding the development of nanocomposite masterbatches and yarns  
  
one objective of the project was to develop synthetic fibers and yarns with inherent antistatic properties, fire retardancy and uv stability. this would be achieved by simultaneously dispersing in the bulk of the fibers three types of nanoparticles, namely: carbon nanotubes (cnts) for antistatic properties, fr-modified layered silicates (lss) for fire retardancy and nano-tio2 for uv stability. three polymers were explored for the preparation of the fibers, in particular polyamide (pa), polyester (pet) and polypropylene (pp).  
  
in this context, different cnt products were developed using the catalytic chemical vapor deposition (ccvd) method. two main types of multi-walled cnts (mwcnts) were widely tested as additives to the polymer matrices, while in order to improve their dispersion in polymers, the cnts were functionalized with appropriate groups. the physical characteristics of the raw and functionalized cnts along with the percentage of functionalization were assessed by sem, tem, raman spectroscopy, and tga. moreover, in order to comply with stricter health and safety rules, dispersions of cnts were developed either in water or ethanol. for this purpose raw and functionalized cnts were used with or without (depending on the cnts type) the addition of the appropriate amount of surfactant.  
  
on the other hand, commercially available layered silicates (montmorillonites) were modified by phosphorous-based flame retardants which were introduced in the galleries of the layered silicates by solution intercalation. the objective was to develop synergistic fr systems that can improve polymers fire retardancy even when used in low concentrations.  
  
following the development of the aforementioned nanoparticles, these as well as commercially available nano-tio2 were dispersed in pa-, pet- and pp- based compounds, first separately in order to define the minimum concentration of each additive required to endow the relevant functionality without impeding spinnability, and then in combinations. following this approach, antistatic polymeric compounds with up to 50 % improvement of fr properties and increased uv stability compared to the neat polymers were obtained.  
  
however, when these compounds were spun into fibers the functional properties were lost, which was attributed to the rearrangement of the nanoparticles during spinning. therefore, the new modified polymers were not used for the production of inherently multifunctional yarns, as originally planned. instead, other approaches were followed to provide the antistatic and fr properties to the final prototypes. despite that, it should be noted that the multi-component and multi-functional polymeric compounds developed in safeprotex can be used in other applications that do not involve spinning (e.g. for the production of compact polymeric parts for automotive applications, where antistatic and fr properties are required). project partners involved in this result (mirtec, nanothinx, gaiker and rescoll), are already exploring potential exploitation routes.  
  
  
technical achievements regarding the development of thermoregulating yarns and fabrics  
  
garments with built-in thermoregulatory properties may help the body to stay within a comfortable temperature range at different activity levels and ambient conditions. integration of phase change materials (pcms) in garments is one way of achieving this property. when the body temperature increases, the pcm melts and absorbs the heat from the body in the form of latent heat (cooling effect). when the temperature drops, the pcm crystallizes and the stored heat is released again (warming effect). the use of pcms incorporated in the garment structure next to the body may thus improve the thermal comfort of the wearer. fabrics with pcms may also be used in an intermediate clothing layer to act as a short term barrier to heat without adding to the volume and thermal insulation, an effect that would be useful for fire-fighters protective clothing in hot climates.  
  
in the safeprotex project pcms were successfully integrated into textile fabrics by means of melt spun bi-component fibers with a sheath/core structure. in this way pcm is permanently trapped inside the core of the fibers. for improved thermal management both polyamide (pa6) and polyester (pet) filament yarns were produced. the pcm had a melting point of about 32â°c and the heat of fusion was about 60 j/g based on total yarn weight. this is significantly higher than state-of-the-art viscose and acrylic yarns with microencapsulated pcm showing latent heats in the range 5-15 j/g. the use of pa6 and pet ensures that the pcm will not leak out from the fibers during use and repeated washing cycles. knitted thermoregulating undergarments were produced using the aforementioned bi-component yarns.  
  
since the pcms used are of the hydrocarbon type they easily diffuse through polyolefin polymers like polypropylene (pp). pp is thus not suitable as a sheath material since the pcm will be lost during use and laundry. to reduce the migration of pcm nanoclay platelets were dispersed in pp. despite a nice exfoliation and dispersion of clay in pp, proven by both x-ray diffraction (xrd) and transmission electron microscopy (tem), the migration of pcm was increased. this was tentatively explained by the formation of micro cracks at the pp clay interface during solid state drawing of the pp fibers.   
  
in southern europe ngos need clothing with enhanced functionality for use in the control of forest and grass fires in the summer. such a need is a protective jacket that is not bulky and that is cool and light and yet can provide protection against short time heat radiation. protection against heat radiation can of course be achieved by increasing the insulation capacity (bulkiness) of a garment. such a garment fits however badly for continuous operation at ambient temperatures around 30-40â°c. in the safeprotex project textile fibers were developed containing a high proportion of pcms where the aim was to provide a barrier against transient thermal radiation without creating a garment with high thermal insulation. the basic principle is to capture the radiated heat energy in the form of latent heat at a moderately high temperature and in this way keep the temperature low next to the body.  
  
in this case, a pcm having a melting point of 45â°c was selected. as long as there is un-melted pcm in the jacket liner, incoming heat is absorbed at 45â°c and the temperature does not rise above 45â°c, resulting in a lower temperature gradient close to the body and thus in a lower heat flow towards the body. in this case the fiber sheath consists of pet. in this way, a thin lining with low thermal insulation was created, which still provides a short term protection against high temperatures. the jacket bearing this liner was tested by the voluntary rescue teams participating in the project and was highly evaluated. cool and comfortable during normal working conditions but giving extra grace to get to safety in a rapidly advancing fire front. the effect has also been verified by lab tests. based on these results, swerea ivf, who was involved in the development of thermoregulating yarns and fabrics, is currently searching for an industrials partner to license the technology.  
  
correspondingly, a liner with a lower transition temperature may be used for cold work. in this case the pcm is molten at normal room temperature and solidifies at low temperature (such as 18â°c) wherein crystallization prevents cooling and gives a heating effect.  
  
  
technical achievements regarding the development of thermochromic materials (masterbatches, yarns, fabrics and sheets)  
  
thermochromic materials were exploited in the project in order to develop systems that alert the user when the temperature rises over a certain value. such systems are particularly useful for people operating under the risk of wild land fires (prototype 2). therefore, the project envisaged the development of thermochromic yarns based on pet, pa and pp and of fabrics produced thereof, which would subsequently be incorporated in specific parts of prototype 2. however, several adjustments had to be made.  
  
as thermochromic additives, microencapsulated leuco dyes that change color at 42, 46 or 50 â°c (temperatures that lead to thermal shock in people in different eu zones) were selected. these were dispersed in three polymers, namely pp, pla and eva, at a concentration of 5 wt %. pet and pa were not applied, since they are processed at high temperatures that degrade the thermochromic dyes. the resulting compounds were used for the production of monofilaments that exhibit the thermochromic effect at the determined temperatures.   
  
however, in order to produce yarns suitable for weaving, the concentration of the thermochromic microcapsules had to be lowered. in this case, the yarns obtained were very light in color at room temperature and thus the thermochromic effect was not evident. it was, therefore, decided to develop thermochromic sheets with a high concentration of dyes instead.   
  
another issue that had to be tackled was the very low stability of the dyes under uv irradiation. in fact, it was found that uv light degrades the thermochromic compounds and thus the sheets should not be continuously exposed to sunlight. the solution proposed was to supply the thermochromic sheets in alumimum foils that protect them from uv. after the sheets are removed from the foil they should be employed for a limited number of uses only, until their color fades off. the sheets may be incorporated in wristbands, in specifically designed pockets of the garment and/or on the helmet. leitat, being responsible for this result, is exploring opportunities to licence the technology.  
  
  
technical achievements regarding the development of photocatalytic yarns based on peek  
  
despite the great research activity during the two decades in search for a photocatalyst with optimal features, titanium dioxide remains a benchmark against which any alternative photocatalyst must be compared. in fact, tio2 has been widely used because it is inexpensive, it is harmless and its photostability is very high. the smaller is the size of tio2 particles, the better are the photocatalytic performances. therefore, in the production of photoactive textile materials, particular attention must be paid in nanoparticles handling according to eu recommendation 07/02/2008 on a code of conduct for a responsible nanosciences and nanotechnologies research.   
  
within safeprotex project a photoactive polymer that can represent a viable and safer alternative to tio2 has studied and produced at pilot scale. the photoactive material is a modified benzophenone compound. chemical modification of polyetheretherketone (peek) promotes the formation of benzophenyl ketyl radicals (bpk) towards hydrogen atom abstraction.  
  
different modified peek polymers were investigated and produced within the project and the sulphonated peek (speek) was selected as the most promising one for different reasons:  
ï­it is very effective in the production of radicals under uv and solar irradiations  
ï­it is easy to produce and the process can be easily scaled-up (at the end of the project ntt was able to produce up to 1-2 kg of sulphonated peek per day).  
  
in the project speek was studied both for the surface treatment of textiles through conventional finishing processes and for the spinning of novel, inherently photocatalytic yarns. in the second case, it was compounded with polyolefines to produce photoactive yarns with good mechanical properties. electron spin resonance (epr) spectroscopy confirmed that the multifilament yarns are promoting the formation of bpk radicals at high concentrations.  
  
ntt has already applied for a patent concerning this technology, while together with tut they are currently exploring commercial applications in collaboration with a industrial companies. in particular, ntt is responsible for the providing speek, tut has provided a protocol for the compounding of polyolefin and speek, a third party will compound the polymers and the company will produre the filament.  
  
  
technical achievements regarding the development of 3d knitted fabrics  
  
3d (spacer) knitted fabrics are used in garments construction to provide insulation against cold or impact protection, among others. aiming to provide cold insulation the fabric should be used as the garmentâs liner. in this case it should have a low thickness in order to not limit the users agility and mobility. on the other hand, thicker spacer fabrics can be used in specific parts of the garment for impact protection.  
  
in safeprotex spacer fabrics with different structures were developed and evaluated for both purposes. however, since impact protection was not a priority for the end-users addressed in the project, only the fabric most suitable for thermal insulation was produced at large scale and incorporated as a liner in prototype 1 (designated for extreme weather conditions). leitat, who developed the spacer fabrics with specific design and properties to be used as thermo-insulative liners is willing to licence the technology.  
  
technical achievements regarding the development of surface functionalizing treatments  
  
alternative textile surface treatments were developed aiming to provide various functionalities required by the end users. in particular the following developments were explored:  
  
ï­development and application of microcapsules containing pcms, aiming to provide thermoregulating efficiency.  
ï­development and application of chitosan microspheres or microcapsules, aiming to provide antimicrobial properties.  
ï­surface application of benzophenone-based compounds, aiming to provide photocatalytic efficiency, self-cleaning and de-polluting properties.  
ï­development and deposition of alkoxysilane nanosols, aiming to simultaneously provide super-hydrophobicity, self-cleaning and antimicrobial properties.  
  
in this context, microcapsules incorporating organic pcms were developed using selected shell polymers and alternative microencapsulation techniques. their application on textiles was explored by padding, coating, lamination and incorporation in sandwich structures (dotcoat system). although it was possible to develop fabrics with thermoregulating properties, the deposition of pcm microcapsules significantly deteriorated their appearance. since an alternative approach to thermoregulation using pcm-containing bi-component fibers was successfully developed in the project, the pcm microcapsules were not used in the prototypes.  
  
similarly, chitosan microspheres with high antimicrobial efficiency were developed by spray drying and subsequently applied on textiles by padding or screen printing. fabrics pre-treatment or application of alternative binders were elaborated in order to improve the wash fastness of the treatment, however with limited success.  
  
concerning the surface application of benzophenone-based compounds, speek was compounded with polyalcohols to produce a photoactive water based polymer dispersion to be applied on fabrics surface through conventional padding processes. composition of the formula and padding process conditions were optimized and by applying them it is possible to produce photoactive surface to both uv and solar irradiation.  
  
epr spectroscopy confirmed that a large amount of active radicals can be generated after irradiation and that the finish can assure stable photoactive performances over the time. characterization of the finished fabrics showed that:  
â¢ photoactive finishing is not affecting mechanical properties.  
â¢ absorption of uv light to promote photoreacting is improving uv barrier properties of the fabrics.  
â¢ antibacterial properties can be assured by the radical species.  
â¢ sulphonated species have a slight impact in flame retardancy.  
â¢ photoactive finish is promoting self cleaning properties and chemical degradations.  
â¢ poor washing resistance was achieved although it did not affect the photoactive properties.  
â¢ hand of the fabrics was too thick!  
  
in the case of alkoxysilane nanosols, multi-functional hybrid polymers were synthesized in lab-scale based on the formulation of nanosol containing major precursors: methyl triethoxysilane (mtes), 3-glycidopropyltrimethoxysilane (glymo), octyltriethoxysilane (otes) and 3-trimethoxysilyl propyl octadecyl dimethylammonium chloride (quat). through the modified sol-gel process, cotton fabrics were successfully coated with a nanolayer of sol-gel based polymer to achieve multifunctional properties. the properties imparted include abrasion resistance, dimensional stability, antibacterial and super-hydrophobicity for self-cleaning. it is worth noting that after the sol-gel treatment, the knitted cotton fabrics not only retain soft handle, but also exhibit improved moisture management. synthetic fabrics were also successfully coated with the optimised formulation of sol-gel based polymer. due to high affinity of sol-gel to synthetic fibres, shorter reaction time could be used in the treatment process. the fast pad-dry-cure process was feasible to apply sol-gel based hybrid polymers on woven fabrics.  
  
following the lab-scale trials, the basic formulation of nanosols based on selected alkoxysilane-based precursors (mtes, glymo, quat) was suggested and the preparation of functional nanosols by controlled hydrolysis, catalysed by inorganic acid (hcl), was optimised. the application process was verified and optimized at pilot-plant and industrial scale and the resulting properties of finished fabrics were evaluated according to relevant standards.   
  
following the optimization of surface functionalization treatments, the fabrics selected to be used as outer layers of the three prototypes (i.e. blended co/pet, co/bio-pa fabrics, including a laminate with pu membrane for prototype 1) were finished and tested. both functional and physiological parameters were assessed including the influence of the finishing on coloration quality. therefore, the compatibility of the nanosol-based finishing system with high-vis. coloration (red, yellow), water-tightness of the membrane, abrasion resistivity, antistatic properties and flame-proof properties of proban pre-finished fabric were proved.  
  
following this approach multifunctional protective textiles were prepared by nanosol-based finishing and lamination for prototypes, as follows:  
  
- prototype 1 (extreme weather conditions): water-repellency, water-tightness, self-cleaning properties, antimicrobial properties, high-visibility, air and microbe impermeability, increased abrasion resistance.  
- prototype 2&amp;3 (wild land fires; first aid medical personnel): water-repellency, water-tightness, self-cleaning properties, antimicrobial properties, flame-proofness ...

# SAFEPROTEX

Project Acronym: SAFEPROTEX

programme & topic: FP7-NMP NMP-2008-4.0-9

Most frequent returning words in objectives:

* ('properties', 54)
* ('protective', 30)
* ('project', 27)
* ('fabrics', 25)
* ('protection', 23)
* ('development', 20)
* ('heat', 19)
* ('garments', 18)
* ('developed', 16)
* ('yarns', 16)
* ('comfort', 15)
* ('fibers', 15)
* ('temperature', 15)
* ('application', 13)
* ('safeprotex', 12)
* ('order', 12)
* ('surface', 12)
* ('thermal', 12)
* ('textiles', 12)
* ('polymers', 12)
* ('conditions', 11)
* ('operations', 11)
* ('materials', 11)
* ('self-cleaning', 11)

executive summary:  
   
the concept of safeprotex concerns the development of protective uniforms, incorporating multiple protective properties and designated for rescue teams operating under complex risky conditions. in particular, three representative risky operations were considered, namely:  
  
ï­emergency operations under extreme weather conditions (floods, hail, etc),  
ï­operations under the risk of wild land fires, and  
ï­operations of first aid medical personnel, potentially exposed to any risk.  
  
the key scope of the project was to address the main limitations of existing protective garments and, in this context, to develop uniforms exhibiting: (a) protection against multiple hazards, (b) physiological comfort, ergonomic design and enhanced mechanical parameters, and (c) extended service life.  
having identified the protective properties required in each operation considered, additional user requirements were defined through close collaboration with end-users. market trends and relevant legislation were also considered in order to set-up the specifications of the garments to be developed.   
  
thereafter, to achieve its objectives, the project followed a bottom-up approach, starting at the nano-level and encompassing the entire value chain of the textile industry. in fact, project partners developed new additives and functionalizing agents, novel fibers and textile structures as well as multi-functionalizing surface treatments. the new developments include the development of thermo-regulating bi-component fibers incorporating non encapsulated phase change materials, of thermochromic polymeric sheets that act as high temperature alert systems when incorporated in the ppe, of 3d knitted liners, providing thermal insulation in low environmental temperatures, and of sol-gel surface treatments providing super-hydrophobicity, self-cleaning and antimicrobial properties, without deteriorating the handle and moisture management properties of the textile. after selection of the most appropriate materials and technologies that can be combined together, three prototype protective garments were produced, one for each type of operation, combining the following protective properties:  
  
ï­prototype 1 (extreme weather conditions): water impermeability, thermal insulation, super-hydrophobicity, self-cleaning and antimicrobial properties, high abrasion resistance in specific parts and thermo-regulation.  
ï­prototype 2 (wild land fires): fr properties, super-hydrophobicity, self-cleaning and antimicrobial properties, uv protection, protection against heat/cooling effect, high temperature alert and thermo-regulation.  
ï­prototype 3 (first aid medical personnel): super-hydrophobicity, self-cleaning, antimicrobial properties, fr, antistatic properties and thermo-regulation.  
  
the design of the garments varied depending on the application and usersâ requirements (e.g. an overall was selected for prototype 1 and two-pieces garments for prototypes 2 and 3). life cycle analysis proved the environmental benefit of the garments developed in safeprotex. the preliminary cost analysis indicated that the total cost of each developed product is competitive enough to create strong market opportunities also taking into account the lower maintenance requirements, as well as the extended duration of use. in addition to the objective lab testing and examination of the new textiles and garments, the prototypes were evaluated by the end users with very positive results and constructive comments for further improvement. three partners have already expressed their strong interest and commitment of exploiting the outcomes of the project by introducing new protective garments in the market.  
project context and objectives:  
the concept of the project concerns the development of protective uniforms, incorporating multiple protective properties and designated for rescue teams under complex risky conditions met in various types of everyday emergency operations.  
  
technological developments and climatic changes have both led to a large increase in the hazards to which humans are exposed. since a garment or a uniform constitutes the safety barrier between the wearer and the source of potential injury, its characteristics will determine the degree of injury suffered in case of an accident or an emergency operation. the steady evolution of health &amp; safety requirements to respond to new types of risks makes it necessary to develop new innovative products and to ensure their reliability. indeed, the range of hazards and the means of combating them continue to grow and become ever more complex. emergency teams are trained to face operations varying from small scale or wild land fires, extreme weather incidents and other complicated situations. even in a given emergency operation, rescue teams are exposed to a variety of risks.   
  
the idea that constituted the basis of the proposed project was to create innovative solutions to address the main limitations of existing protective garments designated for rescue teams and emergency operators. thus, the key scope of safeprotex was to develop uniforms exhibiting the following characteristics:  
  
ï§ protection against multiple hazards   
ï§ physiological comfort and enhanced mechanical parameters  
ï§ extended service life compared to existing protective clothing   
  
in the frame of safeprotex, three representative risky operations were considered and the corresponding protective uniforms were developed as prototypes. more specifically, the project addressed the following operations:  
  
â¢ emergency operations under extreme weather conditions (floods, hail, etc)  
â¢ operations under the risk of wild land fires  
â¢ first aid medical personnel potentially exposed to any type of risk  
  
the protective properties required in each of these cases are:  
  
â¢ for case 1 (emergency operations under extreme weather conditions): hydrophobicity, water impermeability, thermo-insulation, antibacterial properties, weather &amp; wind resistance.  
â¢ for case 2 (operations under the risk of wild land fires): fr and heat protection, uv protection, cooling effect, high temperature alert  
â¢ for case 3 (first aid medical personnel): antibacterial properties, thermo-regulation, antistatic properties, fr and heat protection, uv protection  
  
moreover, some properties are required in all three cases, including self-cleaning properties, enhanced mechanical parameters and comfort properties (heat and moisture transfer, thermoregulation and mechanical comfort).  
  
more specifically, the project focused in the following aspects of protective clothing development:  
  
1. protection against multiple hazards   
  
as indicated above, the hazards that rescue teams are exposed to, particularly in emergency operations, are at the same time multiple and complex. the main protective properties required and targeted within safeprotex are outlined below:   
  
protection against wetting and water permeation  
protection against extreme environment temperatures  
protection against microbial contamination  
protection against fire and associated heat  
protection against uv radiation  
protection against static electricity   
  
since, several different hazards may be simultaneously encountered in a specific situation, the new trend in research and development of protective textiles lies in the combination of various functionalities in order to obtain multi-protective garments. in this context, the project contemplated the exploitation of novel or advanced technologies to reach each of the above functionalities and then to combine the targeted properties. functionalization was achieved through bulk modification of the fibers and surface treatments of the developed textiles. the variety of options available to the consortium regarding both the functionalizing materials and their application technology ensured that multiple protective properties could be simultaneously achieved.  
  
2. physiological comfort, mechanical parameters and ergonomics  
  
personal protective clothing, in the first place, must provide adequate protection against occupational hazards and mechanically inflicted injuries. protective garments should be strong enough and present good mechanical properties, like tear resistance, tensile strength, breaking force and elongation.   
  
moreover, ppe possess a physiological function, protecting the wearer against heat or cold stress and yielding an at least satisfactory wear comfort. protective clothing results in a micro-environment between itself and the body (thermoregulation). workers are then exposed to a heat or cold stress greater or lower than the ambient environment alone, which is a reflection of micro-environment, metabolic rate and time. adjustments to the ambient environment to account for the micro-environment must be formulated as a means to predict heat or cold strain for safety and productivity purposes.   
  
garments without such a physiological function do not only affect our well-being, but with man working they impede his physical and mental performance and they can even be health-damaging.   
  
air permeability is especially important for comfort of outwear and protective textile products: it deals with material behaviour when exposed to still or slowly moving air and also indicates the wind resistance. air permeability is set by standards en 342 &amp; 14058 as 3 levels, depending on comfort feeling it offers.   
  
finally, clothing with good breathability gives workers the opportunity of doing their work without feeling suffocating. this involves thermal resistance (body heat) and water vapour resistance (perspiration) revealed through the cloth and permits the human to feel comfortable when doing his job.  
  
however, textiles functionalization is usually accomplished at the expense of comfort and/or mechanical parameters. indeed, the application of common coatings as well as the incorporation of active agents, such as flame retardants (frs), in textile fibres in the required amounts to bring the desired effects, is generally accompanied by a decrease in mechanical performance and comfort parameters, i.e. breathability, moisture management, handle, etc. therefore, improved ergonomic and comfort properties are becoming essential in order to achieve an optimal balance between protection and performance.  
  
safeprotex exploited recent advances in nanotechnology to avoid these detrimental effects of textiles functionalization. for example, skin sensorial wear comfort (i.e. smoothness and softness) can be retained after the surface application of active nano-materials, not affecting the basic properties of the fabric. the proposed approach to thermo-physiological wear comfort involved the application of phase-change materials (pcms) through innovative processes. finally, the ergonomic wear comfort, i.e. the fit of the clothing and freedom of movements, was considered through the ergonomic design based on user requirements.   
  
3. extension of the service-life of protective garments  
  
an important issue that was addressed in the project is the durability of protective functions. in fact, a common drawback of protective textiles is related to the deterioration of functional properties after use and consecutive washings. the solution proposed in the project to ensure optimal performance over the whole service-life of protective garments was their self-cleaning functionalization or the induction of water and oil repellent properties, in order to minimize washing requirements. in the same context, the maintenance of high breathability may limit contamination coming from the wearer.   
  
4. user &amp; environment friendliness  
  
an important issue when developing protective garments is the environmental aspect of the involved materials and processes. any materials and processes that are harmful to the environment (and humans) should be avoided in order to comply with current legislation and directives (e.g. reach regulation, eco-labels, etc). therefore, such criteria were taken into consideration when selecting fibrous substrates, active agents and treatment application processes.  
  
the distinct scientific and technological (s&amp;t) objectives of the project included:  
  
ï§ the development of new functionalizing nanoadditives.  
ï§ the appropriate modification of nanoparticles (clays and carbon nanotubes), when necessary, and their subsequent dispersion in polymeric matrices for the development of new polymer-based nanocomposites.  
ï§ the development of nanocomposite or bi-component fibers exhibiting superior mechanical performance, flame retardancy, thermal stability, antistatic properties and/or thermo-regulating effects, through the incorporation of layered silicates (clays), carbon nanotubes (cnts), chromic dyes and phase-change materials (pcms).   
ï§ the design and development of new fabrics through the incorporation of novel/functional fibers and components reacting to external impulses.   
ï§ the exploitation of alternative technologies including sol-gel, microencapsulation, finishing, plasma, etc, for the pre-activation and the surface functionalization of textiles.   
ï§ the assessment of any synergistic or antagonistic effects of various textiles treatments.  
ï§ the ergonomic design and development of optimized garment constructions.   
ï§ the realization and evaluation of prototypes corresponding to the hazardous situations (cases) presented in table 1. it should be emphasized, however, that the technological innovations contemplated within safeprotex could also serve for the development of alternative protective equipment as well as in a variety of different applications. the specific prototypes are only representative cases that may prove the efficacy of the projectâs achievements.  
project results:  
technical achievements regarding the development of nanocomposite masterbatches and yarns  
  
one objective of the project was to develop synthetic fibers and yarns with inherent antistatic properties, fire retardancy and uv stability. this would be achieved by simultaneously dispersing in the bulk of the fibers three types of nanoparticles, namely: carbon nanotubes (cnts) for antistatic properties, fr-modified layered silicates (lss) for fire retardancy and nano-tio2 for uv stability. three polymers were explored for the preparation of the fibers, in particular polyamide (pa), polyester (pet) and polypropylene (pp).  
  
in this context, different cnt products were developed using the catalytic chemical vapor deposition (ccvd) method. two main types of multi-walled cnts (mwcnts) were widely tested as additives to the polymer matrices, while in order to improve their dispersion in polymers, the cnts were functionalized with appropriate groups. the physical characteristics of the raw and functionalized cnts along with the percentage of functionalization were assessed by sem, tem, raman spectroscopy, and tga. moreover, in order to comply with stricter health and safety rules, dispersions of cnts were developed either in water or ethanol. for this purpose raw and functionalized cnts were used with or without (depending on the cnts type) the addition of the appropriate amount of surfactant.  
  
on the other hand, commercially available layered silicates (montmorillonites) were modified by phosphorous-based flame retardants which were introduced in the galleries of the layered silicates by solution intercalation. the objective was to develop synergistic fr systems that can improve polymers fire retardancy even when used in low concentrations.  
  
following the development of the aforementioned nanoparticles, these as well as commercially available nano-tio2 were dispersed in pa-, pet- and pp- based compounds, first separately in order to define the minimum concentration of each additive required to endow the relevant functionality without impeding spinnability, and then in combinations. following this approach, antistatic polymeric compounds with up to 50 % improvement of fr properties and increased uv stability compared to the neat polymers were obtained.  
  
however, when these compounds were spun into fibers the functional properties were lost, which was attributed to the rearrangement of the nanoparticles during spinning. therefore, the new modified polymers were not used for the production of inherently multifunctional yarns, as originally planned. instead, other approaches were followed to provide the antistatic and fr properties to the final prototypes. despite that, it should be noted that the multi-component and multi-functional polymeric compounds developed in safeprotex can be used in other applications that do not involve spinning (e.g. for the production of compact polymeric parts for automotive applications, where antistatic and fr properties are required). project partners involved in this result (mirtec, nanothinx, gaiker and rescoll), are already exploring potential exploitation routes.  
  
  
technical achievements regarding the development of thermoregulating yarns and fabrics  
  
garments with built-in thermoregulatory properties may help the body to stay within a comfortable temperature range at different activity levels and ambient conditions. integration of phase change materials (pcms) in garments is one way of achieving this property. when the body temperature increases, the pcm melts and absorbs the heat from the body in the form of latent heat (cooling effect). when the temperature drops, the pcm crystallizes and the stored heat is released again (warming effect). the use of pcms incorporated in the garment structure next to the body may thus improve the thermal comfort of the wearer. fabrics with pcms may also be used in an intermediate clothing layer to act as a short term barrier to heat without adding to the volume and thermal insulation, an effect that would be useful for fire-fighters protective clothing in hot climates.  
  
in the safeprotex project pcms were successfully integrated into textile fabrics by means of melt spun bi-component fibers with a sheath/core structure. in this way pcm is permanently trapped inside the core of the fibers. for improved thermal management both polyamide (pa6) and polyester (pet) filament yarns were produced. the pcm had a melting point of about 32â°c and the heat of fusion was about 60 j/g based on total yarn weight. this is significantly higher than state-of-the-art viscose and acrylic yarns with microencapsulated pcm showing latent heats in the range 5-15 j/g. the use of pa6 and pet ensures that the pcm will not leak out from the fibers during use and repeated washing cycles. knitted thermoregulating undergarments were produced using the aforementioned bi-component yarns.  
  
since the pcms used are of the hydrocarbon type they easily diffuse through polyolefin polymers like polypropylene (pp). pp is thus not suitable as a sheath material since the pcm will be lost during use and laundry. to reduce the migration of pcm nanoclay platelets were dispersed in pp. despite a nice exfoliation and dispersion of clay in pp, proven by both x-ray diffraction (xrd) and transmission electron microscopy (tem), the migration of pcm was increased. this was tentatively explained by the formation of micro cracks at the pp clay interface during solid state drawing of the pp fibers.   
  
in southern europe ngos need clothing with enhanced functionality for use in the control of forest and grass fires in the summer. such a need is a protective jacket that is not bulky and that is cool and light and yet can provide protection against short time heat radiation. protection against heat radiation can of course be achieved by increasing the insulation capacity (bulkiness) of a garment. such a garment fits however badly for continuous operation at ambient temperatures around 30-40â°c. in the safeprotex project textile fibers were developed containing a high proportion of pcms where the aim was to provide a barrier against transient thermal radiation without creating a garment with high thermal insulation. the basic principle is to capture the radiated heat energy in the form of latent heat at a moderately high temperature and in this way keep the temperature low next to the body.  
  
in this case, a pcm having a melting point of 45â°c was selected. as long as there is un-melted pcm in the jacket liner, incoming heat is absorbed at 45â°c and the temperature does not rise above 45â°c, resulting in a lower temperature gradient close to the body and thus in a lower heat flow towards the body. in this case the fiber sheath consists of pet. in this way, a thin lining with low thermal insulation was created, which still provides a short term protection against high temperatures. the jacket bearing this liner was tested by the voluntary rescue teams participating in the project and was highly evaluated. cool and comfortable during normal working conditions but giving extra grace to get to safety in a rapidly advancing fire front. the effect has also been verified by lab tests. based on these results, swerea ivf, who was involved in the development of thermoregulating yarns and fabrics, is currently searching for an industrials partner to license the technology.  
  
correspondingly, a liner with a lower transition temperature may be used for cold work. in this case the pcm is molten at normal room temperature and solidifies at low temperature (such as 18â°c) wherein crystallization prevents cooling and gives a heating effect.  
  
  
technical achievements regarding the development of thermochromic materials (masterbatches, yarns, fabrics and sheets)  
  
thermochromic materials were exploited in the project in order to develop systems that alert the user when the temperature rises over a certain value. such systems are particularly useful for people operating under the risk of wild land fires (prototype 2). therefore, the project envisaged the development of thermochromic yarns based on pet, pa and pp and of fabrics produced thereof, which would subsequently be incorporated in specific parts of prototype 2. however, several adjustments had to be made.  
  
as thermochromic additives, microencapsulated leuco dyes that change color at 42, 46 or 50 â°c (temperatures that lead to thermal shock in people in different eu zones) were selected. these were dispersed in three polymers, namely pp, pla and eva, at a concentration of 5 wt %. pet and pa were not applied, since they are processed at high temperatures that degrade the thermochromic dyes. the resulting compounds were used for the production of monofilaments that exhibit the thermochromic effect at the determined temperatures.   
  
however, in order to produce yarns suitable for weaving, the concentration of the thermochromic microcapsules had to be lowered. in this case, the yarns obtained were very light in color at room temperature and thus the thermochromic effect was not evident. it was, therefore, decided to develop thermochromic sheets with a high concentration of dyes instead.   
  
another issue that had to be tackled was the very low stability of the dyes under uv irradiation. in fact, it was found that uv light degrades the thermochromic compounds and thus the sheets should not be continuously exposed to sunlight. the solution proposed was to supply the thermochromic sheets in alumimum foils that protect them from uv. after the sheets are removed from the foil they should be employed for a limited number of uses only, until their color fades off. the sheets may be incorporated in wristbands, in specifically designed pockets of the garment and/or on the helmet. leitat, being responsible for this result, is exploring opportunities to licence the technology.  
  
  
technical achievements regarding the development of photocatalytic yarns based on peek  
  
despite the great research activity during the two decades in search for a photocatalyst with optimal features, titanium dioxide remains a benchmark against which any alternative photocatalyst must be compared. in fact, tio2 has been widely used because it is inexpensive, it is harmless and its photostability is very high. the smaller is the size of tio2 particles, the better are the photocatalytic performances. therefore, in the production of photoactive textile materials, particular attention must be paid in nanoparticles handling according to eu recommendation 07/02/2008 on a code of conduct for a responsible nanosciences and nanotechnologies research.   
  
within safeprotex project a photoactive polymer that can represent a viable and safer alternative to tio2 has studied and produced at pilot scale. the photoactive material is a modified benzophenone compound. chemical modification of polyetheretherketone (peek) promotes the formation of benzophenyl ketyl radicals (bpk) towards hydrogen atom abstraction.  
  
different modified peek polymers were investigated and produced within the project and the sulphonated peek (speek) was selected as the most promising one for different reasons:  
ï­it is very effective in the production of radicals under uv and solar irradiations  
ï­it is easy to produce and the process can be easily scaled-up (at the end of the project ntt was able to produce up to 1-2 kg of sulphonated peek per day).  
  
in the project speek was studied both for the surface treatment of textiles through conventional finishing processes and for the spinning of novel, inherently photocatalytic yarns. in the second case, it was compounded with polyolefines to produce photoactive yarns with good mechanical properties. electron spin resonance (epr) spectroscopy confirmed that the multifilament yarns are promoting the formation of bpk radicals at high concentrations.  
  
ntt has already applied for a patent concerning this technology, while together with tut they are currently exploring commercial applications in collaboration with a industrial companies. in particular, ntt is responsible for the providing speek, tut has provided a protocol for the compounding of polyolefin and speek, a third party will compound the polymers and the company will produre the filament.  
  
  
technical achievements regarding the development of 3d knitted fabrics  
  
3d (spacer) knitted fabrics are used in garments construction to provide insulation against cold or impact protection, among others. aiming to provide cold insulation the fabric should be used as the garmentâs liner. in this case it should have a low thickness in order to not limit the users agility and mobility. on the other hand, thicker spacer fabrics can be used in specific parts of the garment for impact protection.  
  
in safeprotex spacer fabrics with different structures were developed and evaluated for both purposes. however, since impact protection was not a priority for the end-users addressed in the project, only the fabric most suitable for thermal insulation was produced at large scale and incorporated as a liner in prototype 1 (designated for extreme weather conditions). leitat, who developed the spacer fabrics with specific design and properties to be used as thermo-insulative liners is willing to licence the technology.  
  
technical achievements regarding the development of surface functionalizing treatments  
  
alternative textile surface treatments were developed aiming to provide various functionalities required by the end users. in particular the following developments were explored:  
  
ï­development and application of microcapsules containing pcms, aiming to provide thermoregulating efficiency.  
ï­development and application of chitosan microspheres or microcapsules, aiming to provide antimicrobial properties.  
ï­surface application of benzophenone-based compounds, aiming to provide photocatalytic efficiency, self-cleaning and de-polluting properties.  
ï­development and deposition of alkoxysilane nanosols, aiming to simultaneously provide super-hydrophobicity, self-cleaning and antimicrobial properties.  
  
in this context, microcapsules incorporating organic pcms were developed using selected shell polymers and alternative microencapsulation techniques. their application on textiles was explored by padding, coating, lamination and incorporation in sandwich structures (dotcoat system). although it was possible to develop fabrics with thermoregulating properties, the deposition of pcm microcapsules significantly deteriorated their appearance. since an alternative approach to thermoregulation using pcm-containing bi-component fibers was successfully developed in the project, the pcm microcapsules were not used in the prototypes.  
  
similarly, chitosan microspheres with high antimicrobial efficiency were developed by spray drying and subsequently applied on textiles by padding or screen printing. fabrics pre-treatment or application of alternative binders were elaborated in order to improve the wash fastness of the treatment, however with limited success.  
  
concerning the surface application of benzophenone-based compounds, speek was compounded with polyalcohols to produce a photoactive water based polymer dispersion to be applied on fabrics surface through conventional padding processes. composition of the formula and padding process conditions were optimized and by applying them it is possible to produce photoactive surface to both uv and solar irradiation.  
  
epr spectroscopy confirmed that a large amount of active radicals can be generated after irradiation and that the finish can assure stable photoactive performances over the time. characterization of the finished fabrics showed that:  
â¢ photoactive finishing is not affecting mechanical properties.  
â¢ absorption of uv light to promote photoreacting is improving uv barrier properties of the fabrics.  
â¢ antibacterial properties can be assured by the radical species.  
â¢ sulphonated species have a slight impact in flame retardancy.  
â¢ photoactive finish is promoting self cleaning properties and chemical degradations.  
â¢ poor washing resistance was achieved although it did not affect the photoactive properties.  
â¢ hand of the fabrics was too thick!  
  
in the case of alkoxysilane nanosols, multi-functional hybrid polymers were synthesized in lab-scale based on the formulation of nanosol containing major precursors: methyl triethoxysilane (mtes), 3-glycidopropyltrimethoxysilane (glymo), octyltriethoxysilane (otes) and 3-trimethoxysilyl propyl octadecyl dimethylammonium chloride (quat). through the modified sol-gel process, cotton fabrics were successfully coated with a nanolayer of sol-gel based polymer to achieve multifunctional properties. the properties imparted include abrasion resistance, dimensional stability, antibacterial and super-hydrophobicity for self-cleaning. it is worth noting that after the sol-gel treatment, the knitted cotton fabrics not only retain soft handle, but also exhibit improved moisture management. synthetic fabrics were also successfully coated with the optimised formulation of sol-gel based polymer. due to high affinity of sol-gel to synthetic fibres, shorter reaction time could be used in the treatment process. the fast pad-dry-cure process was feasible to apply sol-gel based hybrid polymers on woven fabrics.  
  
following the lab-scale trials, the basic formulation of nanosols based on selected alkoxysilane-based precursors (mtes, glymo, quat) was suggested and the preparation of functional nanosols by controlled hydrolysis, catalysed by inorganic acid (hcl), was optimised. the application process was verified and optimized at pilot-plant and industrial scale and the resulting properties of finished fabrics were evaluated according to relevant standards.   
  
following the optimization of surface functionalization treatments, the fabrics selected to be used as outer layers of the three prototypes (i.e. blended co/pet, co/bio-pa fabrics, including a laminate with pu membrane for prototype 1) were finished and tested. both functional and physiological parameters were assessed including the influence of the finishing on coloration quality. therefore, the compatibility of the nanosol-based finishing system with high-vis. coloration (red, yellow), water-tightness of the membrane, abrasion resistivity, antistatic properties and flame-proof properties of proban pre-finished fabric were proved.  
  
following this approach multifunctional protective textiles were prepared by nanosol-based finishing and lamination for prototypes, as follows:  
  
- prototype 1 (extreme weather conditions): water-repellency, water-tightness, self-cleaning properties, antimicrobial properties, high-visibility, air and microbe impermeability, increased abrasion resistance.  
- prototype 2&amp;3 (wild land fires; first aid medical personnel): water-repellency, water-tightness, self-cleaning properties, antimicrobial properties, flame-proofness ...

# DESIGN4CHILDREN

Project Acronym: DESIGN4CHILDREN

programme & topic: FP7-SME SME-2

Most frequent returning words in objectives:

* ('children', 48)
* ('information', 43)
* ('products', 41)
* ('comfort', 36)
* ('fitting', 30)
* ('thermal', 29)
* ('tool', 26)
* ('design', 25)
* ('database', 25)
* ('product', 24)
* ('project', 23)
* ('users', 22)
* ('usability', 21)
* ('development', 20)
* ('developed', 20)
* ('results', 19)
* ('interaction', 18)
* ('clothing', 17)
* ('tools', 17)
* ('application', 17)
* ('knowledge', 16)
* ('databases', 16)
* ('body', 16)
* ('criteria', 16)

executive summary:  
  
design4children has been a 3-year project, funded by the european commissionâs 7th framework programme within the âresearch for sme associationsâ scheme. the design4children consortium has been made up of a team of 12 organizations from seven european countries that were selected based on their expertise in fields that were complimentary to the development of the project activities.  
  
the aim of the project has been to provide european smes in the field of children's products, in particular clothing, footwear and childcare industries, with a set of knowledge-based tools addressed to develop high-added value products based on improved comfort, performance and adaptation to the user.  
  
the project was carried in three phases: research, development and validation. the final result is a suite of three products: knowledge-based design support, virtual functional performance test bed, web-based interactive purchase adviser.  
  
the consortium also designed and approved a full plan for ipr management and product exploitation  
  
project context and objectives:  
  
a) the need:  
  
nowadays, when information about products is widely available through the network, providing products with attributes demanded by consumers becomes indispensable to succeed. furthermore, parents demand more and more knowledge about features and characteristics of the products they acquired for their children as well as information based on scientific basis that help them in the process of selection and purchase.  
  
although fashion and price have traditionally been the main aspects motivating the purchase decision of children products, more and more human factors related to comfort, health and usability are becoming relevant and differentiating aspects for consumers of children products.  
  
traditionally, childrenâs products have been designed as if they were addressed to miniaturized adults; however, childrenâs needs related to comfort and usability significantly differ from adultsâ ones. moreover, since birth to adolescence, these needs evolve and change along with children development process and include aspects related to physical interaction (fitting, anthropometry and growth), physiological interaction (thermal comfort), motor aspects (adaptation to movements), psychological interaction (cognitive capacity), or any combination of them (usability and safety of both parents and children).  
  
this new orientation of the product development process to the end-user represented a big competitive opportunity for european children sector, but this involved specific needs:  
  
â¢ acquisition of the necessary knowledge about children-product interaction  
â¢ application of this knowledge into tools allowing its use and exploitation: materialization of r&amp;amp;d advances into value-added products  
â¢ extending this value-chain of knowledge until the customers bringing closer the results, benefits and new functionalities  
  
b) the solution:  
  
d4c initiative arose with the aim of compiling, processing and advancing in knowledge related to children-product interaction with the aim of integrating this knowledge into tools able to make it accessible and understandable for european children companies.  
  
design4children has provided children products companies with innovative knowledge about ergonomics, comfort and adaptation of children products through a set of three innovative tools addressed to implement this knowledge along the process of product development and launching into the market.  
  
sectors under the scope of the project were children fashion, footwear and childcare. the developed tools were:  
  
â¢ a knowledge-based design support application that will help design teams to introduce enhanced functionalities to products and assure childrenâs comfort and wellbeing  
â¢ a virtual functional performance test bed that allows manufacturers to evaluate the functional performance of their design without manufacturing them, which considerably reduces costs and speeds up the creation of products.  
â¢ a web-based interactive purchase adviser accessible via internet, that will help customers and retailers to select the products that better match their childrenâs needs.   
  
these tools represent an innovation for the industry, and will present a market opportunity for those innovative companies which continuously search for competitive advantages by promoting comfort, quality and safety of childrenâs products and innovative product design.  
  
the design4children project comprised of the following set of scientific and technical objectives:  
  
a) scientific objectives  
  
so-1. understanding the interactions child-product-parent for childcare products  
so-2. developing for each functional aspect, a model to simulate and predict the biomechanical and physiological children-product interaction  
so-3. developing two global predictive models for childrenâs comfort and productâs lifespan  
so-4. establishing the specific constraints and specifications of the european sme manufacturers and their distribution channels  
  
b) technical objectives  
  
to-1. development of a knowledge-based support application  
to-2. development of a virtual functional performance test bed  
to-3. development of a web-based interactive product selection adviser  
  
project results:  
  
the d4c project followed a three stages process, starting with r&amp;amp;d activities during the first year of the project, continuing with the development stage during the second phase of the project and finishing with the validation of the three tools developed during the last period.  
  
a) r&amp;amp;d stage  
  
the r&amp;amp;d phase was addressed to understanding the biomechanical, ergonomic and physiological interactions between children products and their users, both children and parents. secondly, the generated knowledge was translated into information and contents for the three d4c tools.  
  
â¢ research on available knowledge and consumers needs  
  
work developed was initiated gathering information about the complex interaction between children products and their users, considering as users both children and parents or other adults in charge of the child. this interaction can be considered as multi-factor including biomechanical, ergonomic and physiological aspects.  
  
ibv developed an analysis of the needs and concerns of customers of children products to increase the added-value of project results. this analysis was based on two user-centered techniques:  
  
o focus groups. they are group conversations in a permissive and non-directive atmosphere designed to obtain information about a topic.  
o netnographic analysis of the main relevant blogs in the web regarding children products.  
  
analysed issues were children and parents interaction with products, users perception of actual products in the market and usersâ preferences and demanded functionalities.  
  
designers of children products, members of the sme project partners participated contributing with their experience in the different fields.  
  
in parallel to the analysis of usersâ needs, ibv performed a scientific review on:  
  
o existing methodologies to analyze children-product interaction regarding the main ergonomic issues: anthropometry, thermoregulation and usability   
o main issues regarding functional properties of the children products  
o existing models and databases regarding fitting, thermal aspects and usability  
  
available anthropometric databases were gathered, differing in measuring techniques, gender, number of children included, age ranges, body dimensions included and statistical parameters used. this involved high heterogeneity of results what involved a later analysis to define a process to give coherence to the available databases.  
  
published studies regarding children thermoregulation were gathered and analyzed. gaps in the knowledge, in particular regarding child-cloth interaction, were identified. ibv studied the applicability of the existing adults thermal comfort models to generate thermoregulatory prediction models for children.  
  
childrenâs usability studies were gathered and analyzed. functional aspects of children products were prioritized according to their impact on both usersâ comfort and product durability.  
  
from the results obtained, the following products were included into the scope of the project:  
  
o childcare products with high anthropometric, biomechanical and physiological interaction with the users (children and parents: pushchairs, baby car seats, baby baths, baby changing units, cradles, baby high chairs, baby rocking chair &amp;amp; swings, baby carriers  
o clothing for children between 0 and 12 years old, including: t-shirts, shirts, blouses, jacket, sweaters and sweatshirts, underwear and pyjamas, trousers, dresses and skirts, accessories (hats, scarves, gloves, socks, etc)  
o footwear for children between 0 and 12 years old, including: casual shoes, sport shoes, dress shoes, boots, sandals, clogs  
  
â¢ experimentation with users to cover the identified lacks of knowledge  
  
ibv worked on defining methodologies to develop experimentations with users for obtaining design criteria for children products, working on the three main research fields involving productâs ergonomics: anthropometry, thermal comfort and usability.  
  
o anthropometry &amp;amp; fitting: a new experimental methodology to capture childrenâs 3d morphology and evaluate clothing fitting in children was set up.  
o thermal comfort: an experimental methodology aimed to validate the thermal comfort prediction model for children was proposed.  
o usability: two methodologies were generated to analyze the product-user interaction:  
\* qualitative analyses of childrenâs-parents product interaction through video-recording and visual expert analysis.  
\* quantitative analyses of childrenâs-parents product interaction through video recording and time and frequency analysis of usersâ behaviors.  
  
functional properties of childcare products were deeply characterized through different user tests following the aforementioned methodologies. results obtained completed the gaps in knowledge previously detected. 24 children from 0 to 8 years old participated in fitting and usability tests.  
  
â¢ definition of design criteria for enhanced functionality and comfort  
  
ibv processed information previously obtained to find the relation between specific design aspects and children and parents comfort perception and usability needs to generate design criteria.  
  
a) generation of fitting criteria for clothing  
  
work developed for obtaining fitting criteria is described below.  
  
a.1) comparative analysis of available international databases regarding children growth, body proportions and relationship among anthropometric variables  
  
the heterogeneity of the databases gathered required a deep analysis to identify the measures that could be used for the tools. databases were compared through the use of growing curves based on height and age, analyzing the differences in body proportions among countries and the capacity of age and height to calculate other body measures. the aim was to obtain rules for the obtaining anthropometric information when no data are available.  
  
slight differences were found in growth among european population and small differences in body proportions, much smaller than the variability found within a single population. it was decided to generate specific growth charts per country to account the differences found.  
  
a.2) generation of international anthropometric databases  
  
building a complete database was a two-steps process: 1) obtaining the relation age-height for each country and 2) obtaining the relation between height and the remaining body measures jointly for all populations. all the relations are polynomial equations.   
  
spain, usa, netherlands and a global international database from who were obtained.   
  
it is possible to include new populations into the d4c tools using the height-age relationships obtained.  
  
a.3) definition of suitable eases for clothing to allow their adaptation to child movements  
  
a bibliographic research was performed, identifying the most compromising body postures in children and defining the related body measures and their variation. finally, the relationship between these body measures and the garment pattern was defined.  
  
results obtained were the maximum increases and decreases that each one of the key dimensions of the cloth pattern can suffer when the child performs different movements.  
  
a.4) generation of fitting criteria for clothing assuring children comfort  
  
experimentation with children allowed obtaining fitting perception from parents after wearing different garments and children anthropometry using tape and 3d scanner. children and garments dimensions were compared to obtain the ease allowances of the garments when worn. ease allowances were correlated with fitting perception in different areas of the body to get the body measures with significant effect on fitting. finally, fitting criteria were defined based on a lower and upper limit for the relation between easy allowances and fitting.  
  
b) generation of fitting criteria for footwear  
  
databases obtained were completed with ibv foot databases. sizes 24, 30 and 36 were selected for the analysis and generation of criteria. a set of children shoes and shoe-lasts in these sizes were selected from the market. lasts were digitalized and measured to extract the dimensions from those girths relevant for fitting: heel, instep, metatarsophalangeal joint and toes. the sample of shoes was evaluated by a sample of users to obtain the fitting perception. last measures were compared with foot anthropometrical data to obtain ease allowances, relating them with comfort perception. the result was for each size and shoe dimension the valid range of the measure and the easy allowance between foot and shoe.  
  
c) definition of thermal models and thermal comfort criteria for clothing and footwear  
  
work started identifying the textile materials most commonly used in the design of children products and collecting their thermal and mechanical properties: thermal resistance (rt), resistance to water vapour (re), thickness and grammage. in parallel, it was analysed the relation between the thermal insulation and perspiration of textiles and their physical variables for different materials. the bibliographic research allowed also characterizing the childrenâs thermoregulatory response during the development of different levels of activity: asleep, low activity, medium activity and high activity. the research also identified the most relevant environmental parameters affecting thermal response.  
  
the results obtained allowed defining a set of thermal comfort recommendations including:  
  
o recommended thermal resistance  
o garment recommendations  
o material recommendations   
  
the analysis of the capability of the mechanical parameters of predicting the thermal parameters allowed establishing relations between both sets of parameters and generating thermal comfort criteria.  
  
d) generation of usability specifications  
  
usability involves every aspect of the product related to facilitate its use, so it includes both children and parents usability. the high level of complexity associated to the concept âusabilityâ led to a qualitative approach to generate worthy and applicable results for designers. results came from different sources:  
  
o consumers needs: information included into d1.1  
o designers and retailers contributions: information included into d2.1 and d2.2  
o expertsâ knowledge: resulting from the development of the different experimental tasks  
  
ibv generated a set of databases containing specifications to improve the product usability. specifications were classified by:  
  
o type of product, using the classification previously mentioned (childcare products, clothing and footwear)  
o functional properties: defined considering the type of interaction between user and product. properties considered are: anthropometry &amp;amp; growth, comfort, durability, thermal comfort, safety, biomechanical performance and general usability.  
o user profile: defined by the age range.  
  
â¢ development of predictive models of functional aspects  
  
the relations extracted between product functional properties and comfort perception were materialized into mathematical models allowing the prediction of most relevant functional properties regarding children comfort and wellbeing: fitting, adaptation to movements, growing, thermal regulation and usability.  
  
o usability criteria: for each product type (clothing, footwear and childcare) it was generated an algorithm that allows the designer to select a set of parameters (product, environment of use and user profile) returning design recommendations for the different functional properties related to the usability of the product and the relative importance of each functional property.  
o fitting: the developed model provides the designer a quantification of the level of fitting the designed cloth has, indicating if it is correct, too loose or too tight. input data are: the type of garment, the garment 2d pattern measures and the target users profile (age and country). the developed algorithm compares body measures of the selected population with the cloth pattern dimensions. the algorithm developed is based on three databases:  
 \* anthropometric database: including for different countries body dimensions relevant for clothing design classified by age  
 \* fitting comfort criteria database: including maximum and minimum coefficients representing the body and garment measures ratios for assuring comfort  
 \* clothing pattern database: including the information about the pattern design of the garment included by the designer for the virtual test  
o adaptation to movements: this model provides the designer a quantification of the adaptation of the proposed cloth to the body changes in dimensions and proportions when performing different movements. input data are the same that for fitting. the developed algorithm uses input information from fitting and compares this information with the dynamic fitting database. this database includes the percentages of variation of the anthropometric measures associated to child movements. the module facilitates the most important clothing measures related to movements adaptation and quantifies the capacity of the designed cloth according to its pattern related dimensions.  
o thermal comfort: this model provides information about the garment or footwear level of insulation and the insulation required for a specific environment and level of activity. input data are the environment conditions, the target user profile and garment parameters including materials of the garments and layers configuration. two different methods for calculating the thermal insulation of garments were proposed, depending on data available for the designer: a) layers method based on lotensâ model and using the thickness of the textiles and b) mass method based on mccullough model and using the weight of the clothing. three complementary approaches were proposed to obtain a complete set of results:  
 \* material based model. this model provides thermal properties of each garment, global thermal properties of the ensemble and material recommendations.   
 \* standard based model. this model provides the allowed exposure time to assure heat storage and to avoid excessive water loss, within comfort levels.  
 \* perception based model. this model provides the predicted perceptual response of a group of people according to the ashrae thermal sensation definition.  
  
â¢ design process characterization and specifications for r1 and r2  
  
we fully characterized the design process of different children companies, detecting barriers and needs for the future implementation of d4c tools r1 and r2. the application of user-centered design techniques provided information directly from future users of the tools regarding their expectatives and needs. focus groups, workshops and questionnaires were used to gather from more general to more specific information regarding the design process and the expected and needed software features.  
  
the analysis of gathered information allowed the generation of specifications for the tools, including the information flows, the needed inputs and the most convenient outputs for the types of products under the project scope: clothing, footwear and childcare. three blocks were established: fitting, thermal comfort and usability  
  
â¢ shopping experience characterization and specifications for r3  
  
the development of different experimental sessions with parents and within the shops in real conditions allowed obtaining consumers and retailers needs and expectations regarding the future tool r3.   
  
interviews with retailers and purchasers of children products and questionnaires were used to gather information from future users.   
  
examples of gathered information are:  
  
o prioritization of most relevant functional aspects of products according to their experience  
o description of the purchase experience  
o customer expectations during the purchase process  
o retailers needs and requirements  
  
the analysis of the results allowed the definition of a set of specifications to assure the integration of the new tool into purchase process. a tool was proposed where:  
  
o customers could access products and provide their experience with them  
o retailers could have information to provide better service to their customers  
o manufacturers could improve their products according to received feedback  
  
results of the rtd stage  
  
after the r&amp;amp;d stage, we:  
  
â¢ had deep understanding of the main aspects related to functional adequacy of different children products as well as children and parents needs  
â¢ got a complete review of the available scientific knowledge, structured and existing gaps identified.  
â¢ developed methodologies to characterize children-products interaction and performed user test to acquire needed knowledge  
â¢ generated design criteria for different functional aspects of product design  
â¢ generated functional models of the interaction between children and products  
â¢ were able to start defining the characteristics, structure and features of the three tools resulting from the project  
â¢ better orientated the integration of the tools at the companies to satisfy future users' needs  
  
b) development stage  
  
during this stage we developed the three web-based applications.  
  
â¢ generation of specifications for the design support  
  
isri produced a list of technical specifications and software requirements that was discussed by project partners. they also proposed the logical architecture of the system, consisting in three layers: presentation or user interface, business logic and data access.   
  
23 use cases were identified and defined, including all the possible interactions of different actors with the tool, for example âedit profileâ or âusability-footwearâ. each use case was described including actors involved, inputs, outputs, information flows and additional information needed for developing the tool. the features to include in the system were explained and the functional requirements detailed. interface requirements, as well as other non-functional requirements were also detailed.  
  
â¢ development of the design support system  
  
for each one of the functional aspects (fitting, usability and thermal comfort) and product types (clothing, footwear, childcare products) to be included into the tool, ibv provided the following information:  
  
o inputs: information that the designer will enter the system  
o outputs: information that the designer should receive  
o databases feeding the algorithms  
o a proposal on how could be the flow of info among these elements  
  
isri developed at three-tier application system including:  
  
o a presentation layer: web user interfaces, it allows users interact with the tool and displays results  
o business logic layer: coordinates the application, processes commands and makes decisions  
o database layer: includes stored information accessed during the use of the application  
  
the developed application provides user friendly interface that allows access to essential information for enhanced product design considering the childâs comfort and well being. the relevant information is provided based on the selection of the product, childâs age, gender, environment and product target country depending on the product category. the design support tool enables the designer to access information on child anthropometry and, most importantly, expert advice on proposed measures, usability and thermal comfort. the application was developed so that additional information can be included an updated as it becomes available.  
  
isri performed the testing of the tool following a defined protocol to assess it under real conditions. the system was extensively tested and verified with chrome, safari and internet explorer (version 8). to access the system, a computer connected to the internet is required. the computer should have a web browser installed.   
  
â¢ generation of specifications for the virtual tester  
  
browzwear produced software requirements specification (srs) and routes for the development of the functional aspects and the interface of the virtual tester. project companies and the other rtds participated providing their input as final users of the tool.  
  
a structure for the application and the different features to include were proposed. each feature was described including inputs needed, outputs provided and requirements. the structure and information contained in each of the databases managed by the application were defined. finally, 12 use cases were proposed, including all the possible interactions of different actors with the tool, for example âforget passwordâ or âcloth fitting testâ. each use case was described including actors involved, inputs, outputs, information flows and additional information needed for developing the tool.  
  
â¢ development and integration of the virtual tester system  
  
four modules were developed based on the results obtained the research phase of the project:  
  
o clothing fitting. this module uses anthropometric database, fitting comfort criteria database and 3d avatar database.  
o clothing thermal comfort. this module uses materials database, anthropometric database, cloth types database, metabolic rates database and environmental database.  
o footwear fitting. this module uses foot anthropometric database and fitting comfort criteria database.  
o footwear thermal comfort. this module uses anthropometric database, materials database and shoe database.  
  
browzwear wrote the code of the different modules of the tool and debug the software. this included the integration with all systems, the management of information flows among modules and the way they are interweaved with the software interface. the predictive models resulting from the research phase, programmed in matlab, were translated into javascript language. an initial qa was performed. this interface manages multiple information databases gathered during the d4c project. the databases are stored in the form of xml files.  
  
a simple, user-friendly interface was developed for carrying out anthropometric and thermal calculation models based on parameters such as the size of a body, gender, age, climate conditions and other information. as the software is not intended for expert computer users, simplicity and user-friendliness were initial requirements. as a result, complete functional version of the virtual-tester was created.  
  
â¢ testing and validation of the virtual tester  
  
ibv and browzwear performed an in-depth analysis of the information provided by the virtual tester software, comparing the results provided by the tool with the results of the initial predictive models obtained from the work package one, with the aim of detecting possible errors in the implementation of the predictive models. in addition, it was reviewed the graphical interface with the user to detect possible improvements. the aesthetic appearance of the interface was also reviewed and compared with the design support tool, the first tool finished in the project. the purpose was giving the three tools a common appearance according to the project image.  
  
the tool was tested on various platforms and with various browsers to check its adequacy a correct performance of all menus. it was checked the correct performance of the tool in any 4th generation browsers supporting forms, css 3.0, html 5.0 and javascript.  
  
a continuous process of redesign and validation of the implemented improvements was performed. the modules of the tool were checked according to all the possible scenarios of use. the tool was also prepared in full multilingual support for facilitating the future translation into new languages prior to the exploitation in different countries. this multilingual support built in allows easily add new languages.  
  
the virtual tester requires the following software in order to function properly: jquery v.1.7+ and any 4th generation browsers supporting forms, css 3.0, html 5.0 and javascript. this system has no specific hardware interface requirements; there are no memory constraints.  
  
the software has two modes of performance:  
  
o administrative mode: in this mode, vt allows for   
 \* creating, modifying, deleting of user accounts.  
 \* installing software and database updates.  
 \* functions available in client mode are also available in this mode.  
o client mode: in this mode, users are able   
 \* to login,   
 \* to select anyone of 4 vt components,   
 \* to enter their data and   
 \* to get results  
  
â¢ generation of specifications for the purchase adviser  
  
isri and ibv defined the functionalities of the tool and its features. the role of the different users was detailed and the information flows described. three possible users of the tool were defined: user (parent/buyer), manufacturer and administrator. the functional requirements of the application were defined, including the different interfaces and operating environment. other non-functional requirements were also detailed.  
  
isri defined the whole set of possible use cases, 16 in total, defining the needed input, provided output, information flows and special requirements among other information. the requirements of the application were defined, including interfaces and operating environment.  
  
â¢ development of the purchase adviser  
  
isri, supported by ibv, used the information generated to develop a multi-tier system that is made up of different functioning levels of the purchase-adviser tool, including the interface characteristics and databases. each functioning level acts as an information provider and receiver, each with its specific characteristics. ways of enabling the input and output of information established in the previous task were defined and developed, and the main interests of the users of each functioning level was considered to define the most important features of the interface.  
  
next step was the integration of the work developed to create the purchase-adviser, a web-platform for customers (mainly parents), retailers and product developers. the web-platform has been developed using appropriate web-development technologies providing users with the guidelines in an interactive and easy to use manner. the purchase-adviser has been connected efficiently with the design-support and virtual-tester tools. within this task, a preview to develop an in-shop device providing online access to the purchase-adviser during the product selection process at the points of sale was carried out.  
  
the application and database is built to support english but designed so that it may be translated for its exploitation at a later stage by the partners. the application is developed in asp.net, c#, html, css, javascript, jquery using visual studio 2010 and database using sqlserver 2008.  
  
the software tool is a web based application. the user interface is compatible with standard microsoft windows desktop browser and a selected android device within the scope of the project. this application will also consider operation on an touch screen android device platform (google nexus 10).  
  
the tool has two modes of performance:  
  
o users: they are parents and retailers who will use the tool for consultation about functionally enhanced features for the selection of children products.  
o system administrator, who manages the database, registration and access rights of users  
  
results of the development stage  
  
after the development stage:  
  
â¢ we created the design support, a sy ...

# ASTEX

Project Acronym: ASTEX

programme & topic: FP7-PEOPLE FP7-PEOPLE-2012-IEF

Most frequent returning words in objectives:

* ('textile', 19)
* ('textiles', 17)
* ('research', 15)
* ('ancient', 13)
* ('project', 8)
* ('terminology', 6)
* ('east', 6)
* ('terms', 6)
* ('study', 5)
* ('culture', 5)
* ('empire', 5)
* ('results', 5)
* ('scholars', 5)
* ('importance', 5)
* ('garments', 5)
* ('societies', 5)
* ('material', 4)
* ('impact', 4)
* ('sources', 4)
* ('texts', 4)
* ('middle', 4)
* ('fellow', 4)
* ('present-day', 3)
* ('knowledge', 3)

final report summary  
astex (assyrian textiles: a study on the terminology and the material culture of the textiles in the neo-assyrian empire, no. 326501)  
  
overview of results and impact of the project  
  
the project was aimed at collecting and analysing the textiles in the sources of the neo-assyrian empire (9th to 7th centuries bc). the research was intended to fill gaps in the present-day scholarly knowledge about textiles in the first-millennium bc ancient near east. previous assyriological scholarly works on mesopotamian textile terminology focused on sumerian texts, second-millennium bc akkadian texts from the city of mari and some of the archival documents from the neo-babylonian period. no specific study has previously been devoted to the textiles attested in written sources of the assyrian empire. the progress in the publication of the assyrian texts from both the first and second millennia bc by international scholars has made this project timely and relevant in assyriology.  
the major research goals of the project concerned the investigation of the whole terminology of textiles in the written documents stemming from all the neo-assyrian archives. the assyrian vocabulary of textiles has been analysed within the broad linguistic context of assyria in the first millennium bc, characterized by the persistence of second-millennium assyrian terms and hurrian loanwords and of new words from west semitic languages. the analysis has also included a comparison with old and middle assyrian attestations, in order to evaluate phenomena of continuity and change in the lexicon of the assyrian material culture. the results achieved will now enable scholars to update some of the translations for textile terms included in the major dictionaries of assyrian language.  
thanks to training in textile techniques, tools, and materials at the host institution, the fellow reached a deeper awareness of textile production that led him to identify some of the textile procedures on which the assyrian terms are based. the meaning of these terms, both those of genuinely assyrian descent and those belonging to the common first-millennium akkadian terms, has been investigated in light of the present-day knowledge of textile techniques and tools in experimental archaeology and ethnographical evidence. these lexical data document the late development of akkadian terminology of textiles in mesopotamia, reflecting circulation of new products and materials within the palace milieu, orientation of textile production and consumption towards specific products and enlargement of the trade network of assyriaâs economy.   
the research has also shown the importance to use material culture in the elucidation of the textual data about textiles, thus combining the traditional lexicological approach within the new perspective of interdisciplinarity between archaeology, history of technology, tool studies and iconography. this can be seen, for instance, in the case of the rich decorative elements from the nimrud tombs that originally adorned the garments of the buried assyrian queens. these textile-related items, whose importance has been underestimated by archaelogists, are probably the star-shaped and the rosette-shaped objects mentioned in the contemporary neo-assyrian texts. the same elements are also represented in the royal garments depicted in the assyrian palace reliefs now kept in various museums. analogous observations may be made about certain qualifications for parts or decorative details of garments, which were not completely understood by scholars and which can be explained using pictorial representations of garments from palace bas-reliefs. therefore, research combining different sources and methodologies has the potential to reach a deeper understanding of the realia of ancient civilizations.  
in order to increase their impact in the field of interdisciplinary research, the mid-term results of the projects were presented in the second international conference on textile terminologies, textile terminologies from the orient to the mediterranean and europe 1000 bc â ad 1000, held in copenhagen and co-organized by the fellow. this represented an opportunity to share ideas on textile terms and techniques with experts in other ancient languages and to reconsider the assyrian textile nomenclature within the broader perspective of first-millennium societies, from east to west. the research on the assyrian textiles was also presented in an outreach seminar entitled meaning and symbolism of textiles and clothing in ancient and modern societies, organized by the fellow at the national museum of denmark with specialists of different disciplinary fields. this event was aimed at disseminating research results towards the public of non-specialists about the role of textiles in both profane and religious contexts in ancient and modern societies, thus giving full visibility of the work currently carried out by european scholars on textiles used in the ancient near eastern, mediterranean, and scandinavian societies. non-academic people participating in this event were interested to learn about the religious representations decorating the royal garments of the assyrian kings and how these were used to convey religious ideas in the neo-assyrian political discourse.  
the results of this project, disseminated through lectures and publications, confirm the importance to continue the research on the terminology of textiles in the sources of the ancient near east in the first millennium bc. it has also the potential to be integrated into new projects aimed at comprehensively studying the neo- and late babylonian archival documents dealing with textiles. given the important cultural legacy of the assyrian empire, the first world empire, in the later civilizations of iraq and of the ancient near east, the knowledge of the assyrian roots of the later aramaic and arabic textile terminologies is of paramount importance in the present-day research on the history of textile manufacture in the middle east. the preservation of this cultural legacy concerning the assyrian textile terminology has an impact not only in historical research. seen in the perspective of long-term impact on the academic community and general society, this work represents another important contribution to ongoing international efforts to preserve, defend, classify, and study the huge cultural heritage of ancient iraq, the land of the two rivers (âmesopotamiaâ), for next generations of scholars. in the field of european research excellence in the humanities area, this project has demonstrated the importance of integrating philological and historical research with material culture studies and ethnography in the understanding of ancient textile procedures and function of textile end products. it is hoped that future cooperation initiatives between eu and middle eastern countries for the preservation and study of the rich textile traditions in the middle east will take into consideration the significant role played by eu-based textile research as a new scientific and truly interdisciplinary domain in the study of the economy, society, and culture of the ancient near eastern civilizations. more importantly, its contribution to the understanding of the role of textiles in shaping ancient and modern societies must be stressed, also in future studies.  
as a final outcome of this project the fellow has written a number of published and forthcoming conference articles and book chapters focusing on different aspects of the assyrian textiles and their roles in the assyrian society. in addition, one manuscript is currently in preparation and will appear in an ancient near eastern scholarly series.  
  
  
project website: http://cordis.europa.eu/project/rcn/108484\_en.html  
  
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the major research goals of the project concerned the investigation of the whole terminology of textiles in the written documents stemming from all the neo-assyrian archives. the assyrian vocabulary of textiles has been analysed within the broad linguistic context of assyria in the first millennium bc, characterized by the persistence of second-millennium assyrian terms and hurrian loanwords and of new words from west semitic languages. the analysis has also included a comparison with old and middle assyrian attestations, in order to evaluate phenomena of continuity and change in the lexicon of the assyrian material culture. the results achieved will now enable scholars to update some of the translations for textile terms included in the major dictionaries of assyrian language.  
thanks to training in textile techniques, tools, and materials at the host institution, the fellow reached a deeper awareness of textile production that led him to identify some of the textile procedures on which the assyrian terms are based. the meaning of these terms, both those of genuinely assyrian descent and those belonging to the common first-millennium akkadian terms, has been investigated in light of the present-day knowledge of textile techniques and tools in experimental archaeology and ethnographical evidence. these lexical data document the late development of akkadian terminology of textiles in mesopotamia, reflecting circulation of new products and materials within the palace milieu, orientation of textile production and consumption towards specific products and enlargement of the trade network of assyriaâs economy.   
the research has also shown the importance to use material culture in the elucidation of the textual data about textiles, thus combining the traditional lexicological approach within the new perspective of interdisciplinarity between archaeology, history of technology, tool studies and iconography. this can be seen, for instance, in the case of the rich decorative elements from the nimrud tombs that originally adorned the garments of the buried assyrian queens. these textile-related items, whose importance has been underestimated by archaelogists, are probably the star-shaped and the rosette-shaped objects mentioned in the contemporary neo-assyrian texts. the same elements are also represented in the royal garments depicted in the assyrian palace reliefs now kept in various museums. analogous observations may be made about certain qualifications for parts or decorative details of garments, which were not completely understood by scholars and which can be explained using pictorial representations of garments from palace bas-reliefs. therefore, research combining different sources and methodologies has the potential to reach a deeper understanding of the realia of ancient civilizations.  
in order to increase their impact in the field of interdisciplinary research, the mid-term results of the projects were presented in the second international conference on textile terminologies, textile terminologies from the orient to the mediterranean and europe 1000 bc â ad 1000, held in copenhagen and co-organized by the fellow. this represented an opportunity to share ideas on textile terms and techniques with experts in other ancient languages and to reconsider the assyrian textile nomenclature within the broader perspective of first-millennium societies, from east to west. the research on the assyrian textiles was also presented in an outreach seminar entitled meaning and symbolism of textiles and clothing in ancient and modern societies, organized by the fellow at the national museum of denmark with specialists of different disciplinary fields. this event was aimed at disseminating research results towards the public of non-specialists about the role of textiles in both profane and religious contexts in ancient and modern societies, thus giving full visibility of the work currently carried out by european scholars on textiles used in the ancient near eastern, mediterranean, and scandinavian societies. non-academic people participating in this event were interested to learn about the religious representations decorating the royal garments of the assyrian kings and how these were used to convey religious ideas in the neo-assyrian political discourse.  
the results of this project, disseminated through lectures and publications, confirm the importance to continue the research on the terminology of textiles in the sources of the ancient near east in the first millennium bc. it has also the potential to be integrated into new projects aimed at comprehensively studying the neo- and late babylonian archival documents dealing with textiles. given the important cultural legacy of the assyrian empire, the first world empire, in the later civilizations of iraq and of the ancient near east, the knowledge of the assyrian roots of the later aramaic and arabic textile terminologies is of paramount importance in the present-day research on the history of textile manufacture in the middle east. the preservation of this cultural legacy concerning the assyrian textile terminology has an impact not only in historical research. seen in the perspective of long-term impact on the academic community and general society, this work represents another important contribution to ongoing international efforts to preserve, defend, classify, and study the huge cultural heritage of ancient iraq, the land of the two rivers (âmesopotamiaâ), for next generations of scholars. in the field of european research excellence in the humanities area, this project has demonstrated the importance of integrating philological and historical research with material culture studies and ethnography in the understanding of ancient textile procedures and function of textile end products. it is hoped that future cooperation initiatives between eu and middle eastern countries for the preservation and study of the rich textile traditions in the middle east will take into consideration the significant role played by eu-based textile research as a new scientific and truly interdisciplinary domain in the study of the economy, society, and culture of the ancient near eastern civilizations. more importantly, its contribution to the understanding of the role of textiles in shaping ancient and modern societies must be stressed, also in future studies.  
as a final outcome of this project the fellow has written a number of published and forthcoming conference articles and book chapters focusing on different aspects of the assyrian textiles and their roles in the assyrian society. in addition, one manuscript is currently in preparation and will appear in an ancient near eastern scholarly series.  
  
  
project website: http://cordis.europa.eu/project/rcn/108484\_en.html  
  
contact details:  
  
salvatore gaspa  
tel.: +0039-3486409942  
e-mail: gaspasal@libero.it   
the danish national research foundationâs centre for textile research  
saxo institute, university of copenhagen  
karen blixensvej 4  
2300 copenhagen s  
denmark

# TAGS

Project Acronym: TAGS

programme & topic: FP7-NMP NMP.2011.2.3-3

Most frequent returning words in objectives:

* ('project', 14)
* ('research', 13)
* ('end-users', 10)
* ('products', 9)
* ('textile', 8)
* ('care', 8)
* ('consortium', 8)
* ('development', 8)
* ('innovation', 7)
* ('field', 7)
* ('materials', 7)
* ('information', 7)
* ('textiles', 7)
* ('institutions', 6)
* ('requirements', 6)
* ('partners', 6)
* ('technology', 5)
* ('manufacturers', 5)
* ('industry', 5)
* ('experts', 5)
* ('tags', 4)
* ('areas', 4)
* ('transfer', 4)
* ('manufacturing', 4)

project context and objectives:  
the fundamental goal of the tags project is to improve the state of current textile solutions for age associated problems, or initiate the innovation of new textile based products in the field of elderly care concentrating in the areas of bedding, clothing, hygiene, and therapy. this is achieved through the building of a consortium which brings together the elderly, social and medical care institutions, research institutions, textile and materials technology transfer institutions and industrial manufacturers. the consortium will be able to help to identify and bring together: the specific requirements of the elderly and care institutions, and the latest developments in materials science and technology that will help meet these requirements, including strategies to incorporate developments in the manufacturing chain and approaches to bring products to market.  
tags has the following objectives:   
â¢ identify new materials, production techniques, and technologies, based on demands and requirements formulated by end-users and industry that can improve the performance of textile products for the elderly.  
â¢ assess the scope, boundary conditions for innovation, and identify barriers preventing progress.  
â¢ set up systems for active discussion and dissemination of information between partners, and provide public with access to general information.  
â¢ generate new joint and collaborative concepts, initiate joint research activities.   
â¢ identify standards, specifications for products and formulate recommendations for policy makers.  
  
an important component is to increase the communication and understanding between stakeholders concerned with the development and use of âtextiles for an ageing societyâ. by bridging the gaps that exist between research organisations, industry/manufacturing and the end-users, the challenges faced by europeâs ageing population can be more clearly identified and addressed thus building a truly multidisciplinary team with experience to tackle further challenges. with this in mind, the project partners who have committed to the tags project cover a range of backgrounds each with a unique perspective of the challenges faced. partners in the consortium are as follows.   
  
1. uibk - universitaet innsbruck - austria - university - textile chemistry and physics  
2. titk - thã¼ringisches institut fã¼r textil- und kunststoff-forschung e.v. - germany - research institute - polymer science and production  
3. niri - nonwovens innovation & research institute ltd. - uk - sme - research institute in the area of nonwovens  
4. warmx - warmx - germany - sme - knitted structures and manufacturing  
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6. staff - staff jersey - italy - sme - knitted structures and manufacturing  
7. conn - connexia â gesellschaft fã¼r gesundheit und pflege gem. gmbh - austria - end-user - health and social care providers  
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project results:  
to date, tags has completed research in the areas of bedding, clothing, hygiene and therapeutic textiles. information on each topic has been collected using the following methods: a literature review to gain a broad understanding of existing and emerging technologies; analysis of sales and market opportunities; questionnaire and semi-structured interviews with care home staff, relatives and end-users.   
project meetings were held bi-annually over the course of the project that were attended by consortium members and invited external experts. these meetings included lectures from external experts from their area of expertise and brainstorming sessions and discussion rounds for each project topic. an outcome of the project meetings is the creation of true multi-disciplinary relationships that will endeavour to build new research teams and to further the development of new ideas generated.   
as part of each meeting, visits to consortium partners and visits to companies outside the consortium served as a basis for increasing the diffusion of knowledge between consortium, partners on areas and issues which were previously unknown to them, which has been instrumental in shaping new project ideas.   
  
potential impact:  
textiles are an integral part of everyday life and are usually taken for granted, however they have a huge potential to support daily activities, and often the consumer does not realise their importance.  
the impact of the project is expected to reach a wide audience ranging from end-users through to manufacturers in order to highlight how textiles can benefit or aid independence and quality of life through innovation.   
  
at the level of end-users  
â¢ the project will offer a platform for end-users to convey their desires and requirements.  
â¢ end-users will obtain direct information on the state-of-art in the development of new products, their opportunities and risks.   
â¢ awareness about needs of the elderly, who represent a big share of eu people, will increase among the scientific community and manufacturers.  
â¢ demands of end-users on textiles will be recognised and psychological preventing innovation will be overcome.  
â¢ there will be significant contribution to the improvement of the quality of lives for the elderly and also of the working practices of the care-givers.  
â¢ caregivers will gain better understanding of materials they use which will lead to their improved competence in given field.  
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at the level of industry   
â¢ industry will benefit from access to scientific experts, graduates and technicians, state-of-the art, research and development facilities in academia.  
â¢ exploitation of new materials will help to develop new products based on the requirements of ageing people, overcoming of european paradox.  
â¢ manufacturers will have direct access to the requirements of end-users.  
â¢ opportunities will be created to develop with end-users a mutually understandable set of definitions and specifications of quality and performance.  
â¢ initiation of joint activities will lead to new competitive products and will open new markets for the industry.  
â¢ new areas of textile application will open.  
â¢ by offering solutions, the ability of european enterprises to compete in the global marketplace will foster.   
â¢ establishment of new contacts and co-operations, strengthening of exiting innovation networks will be supported.  
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â¢ new business opportunities will be promoted through sharing of knowledge not only between industrial, research and end-user sector, but also between eu member states.  
  
at the level of research and technology transfer institutions  
â¢ they will be recognised as experts in the field of materials and products for an ageing society.  
â¢ improved access to the development and marketing concept, and business information.  
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â¢ development of new research activities.  
â¢ establishment of the stable network between partners, fostering mutual trust, strengthening of their competence in a given field.  
â¢ increase attractiveness of universities for industrial collaborations.  
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â¢ the activity of the project will boost development in the field of products for ageing society. skills and creativity of europe will become broader.  
â¢ the consortium will demonstrate examples of active cooperation which will initiate other institutions to follow.  
â¢ active work in the field of textiles for an ageing society will demonstrate the capability of european countries to enhance quality of european citizens.  
â¢ initiation of new product development and product design will strengthen european industrial competitiveness.  
  
list of websites:  
  
http://www.textilesforageingsociety.eu/

# TAGS

Project Acronym: TAGS

programme & topic: FP7-NMP NMP.2011.2.3-3

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list of websites:  
  
http://www.textilesforageingsociety.eu/

# CREATION

Project Acronym: CREATION

programme & topic: FP7-PEOPLE FP7-PEOPLE-2009-IEF

Most frequent returning words in objectives:

* ('textiles', 13)
* ('skin', 7)
* ('human', 5)
* ('hand', 5)
* ('objectives', 3)
* ('project', 3)
* ('creation', 3)
* ('perception', 3)
* ('textile', 3)
* ('research', 3)
* ('development', 3)
* ('methodology', 3)
* ('stimulation', 3)
* ('fellow', 3)
* ('career', 3)
* ('concept', 2)
* ('estimation', 2)
* ('measurement', 2)
* ('part', 2)
* ('multidisciplinary', 2)
* ('engineers', 2)
* ('neurologists', 2)
* ('ghent', 2)
* ('university', 2)

the objectives of this project are the creation and verification of a complex way of analysing the effects of textiles on human organisms and the perception of that textile by humans in respect of their influence on skin. the underlying concept of the research is based on the development of a methodology concerning the estimation of hand of textiles by the three independent inputs. the first one is creating the model of hand of textiles based on the human skin anatomy and physiology. the skin transfers the impulses generated in the human organism coming from the stimulation by the textiles. the second one is performing the subjective hand measurement - perception of textiles by the individuals. this part is based on physical test in volunteers having a contact with different textiles. finally, the third part is the objective hand measurement, total-hand-value (thv) measurements, which is performing the mechanical tests on selected textiles samples. the collection of these three aspects allowed for creation of novel and unique methodology for estimation of hand of textiles. this methodology utilises a three-dimensional (3d) finite element modelling of human skin versus mechanical, thermal stimulation of skin by the textiles. thus, the final phase consists on creation a sensorial process modelling based on stimulation of human skin by textiles. the objectives were achieved through multidisciplinary research of textile engineers, anatomists, neurologists from ghent university and ghent university hospital. this project is tailored in order for the fellow to reach well-defined objectives in terms of career advancement. the schedule and the framework of a main research concept is a complement of the training activities and a personal career development plan, which head for a development of the scientific skills and knowledge of the fellow and a support of a fellow at present stage of her career, an enhancement of her competence diversification in terms of new skills acquisition at multidisciplinary level. the project aroused a consciousness of textiles engineers, textile industry related to production of skin-friendly textiles, physiologists, neurologists in reference to the perception of textiles through the skin and its possible impact on final purchase behaviour of the consumers.

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# INTERCOM

Project Acronym: INTERCOM

programme & topic: FP7-PEOPLE FP7-PEOPLE-2011-CIG

Most frequent returning words in objectives:

* ('architectures', 9)
* ('textile', 8)
* ('composites', 8)
* ('analysis', 7)
* ('damage', 6)
* ('tools', 6)
* ('developed', 6)
* ('scale', 5)
* ('approach', 5)
* ('project', 5)
* ('intercom', 5)
* ('novel', 4)
* ('design', 4)
* ('fibre', 4)
* ('architecture', 4)
* ('material', 4)
* ('interaction', 4)
* ('deformation', 4)
* ('component', 4)
* ('volume', 4)
* ('variation', 4)
* ('techniques', 3)
* ('application', 3)
* ('performance', 3)

new inter-scale techniques for damage analysis of novel composite architectures  
  
in a race for efficiency and functionality modern composite become increasingly complicated. at present, the design of fibrous architectures is often tailored to a specific application and optimised for a particular aspect of composite performance. as a result, fibres are organised in complex curved interlaced trajectories and patterns. every single fibre tow in such architecture may have its own individual path. this level of sophistication becomes typical for the entire suite of composite manufacturing processes ranging from laminated geometries obtained by automatic fibre deposition to intrinsically complex net-shaped textile preforms.  
the essential material properties such as stiffness, toughness, strength depend on the interaction of composite constituents at the scale of fibre bundles/yarns/tows. to understand and predict deformation and damage processes, the internal structures of these materials need to be examined with a high resolution. this implies high computational cost of analysis since the fine geometrical features (characteristic sizes of mm and sub-mm) need to be taken into account at the component scale. thus, the new manufacturing trend creates a need for simple and rational design tools that would allow a fast but comprehensive assessment of the composite performance at the structural and component scales.   
  
modelling approach  
the conventional multi-scale techniques address the challenge of high-resolution â low computational cost by establishing a hierarchy of problems at the component and structural levels. the problem at lower level is typically set for an elementary building block of internal architectures known as representative volume element. this project developed a strategy where the separation of scales is applied to the composites lacking a characteristic representative element through space and scale separation.   
it was demonstrated that a complex interaction of unit cells in an arbitrarily nested, and hence, non-periodic textile laminate can be successfully replicated by the analysis of a single unit cell repeat. the key to the efficient deformation analysis is the boundary conditions set on the surfaces of considered structural element and imitating its interaction with the neighbours. the feasibility of generalising this concept was then tested in application to more complicated architectures and loading cases.   
  
test cases  
the applicability and limitations of the proposed modelling concept were examined in a large number of parametric tests problems reproducing the key features of real architectures such as in-plane and out-of plane waviness of fibres, ply crimp, variation in thickness, etc. these test cases were aimed at validating the decomposition approach against the reference solutions obtained at a realistic computational cost. these studies allowed to extend the applicability of classical multi-scale methods beyond the conventional textile architecture and assess the predictive capacity of the approach towards modelling tow-steered, non-crimp, and patterned materials.   
  
numerical tools developed within the project  
a library of new numerical tools was developed within the project. they enabled generating realistic geometrical models of patterned textile reinforcement with imposed features such as thickness variation, distortions, ply curvature and take into account characteristics which are ignored in conventional model but are essential for understanding consolidation mechanisms and fine peculiarities of the load flow in textile composites (such as lateral yarn interaction, side yarn crimp, curvature of textile plies, etc).   
the logistics of data flow between the defragmented elements of the architecture demanded novel numerical approaches. this included the transformation of vector field into nodal boundary conditions, the tools for post-processing and superposition of 3d displacement fields, the tools for meshing complex architectures, and post-processing algorithms.   
  
novel architectures   
the particular attention of intercom was devoted to the characterisation and analysis of real composite architectures obtained using both the conventional and innovative manufacturing methods. in particular three characteristic case studies were examined in details:   
(a) laminated composites obtained by tow steering. steered architecture are characteristic for high in-plane curvature of tow paths, ply thickness variation, resin rich zones, etc.  
(b) woven architectures patterned through liquid resin print. they feature yarn crimp, superposition of textile and print induced patters, fibre volume fraction variation.   
(c) composites with graded dissimilar matrices and complex distribution of additives applied to redistribute the load around the stress concentration sites.  
an experimental testing programme was conducted for these material systems with the focus on the deformation and damage accumulation mechanisms at the tow/yarn scales.   
  
application of the decomposition approach to model damage  
the high resolution assessment of stress distribution allowed modelling damage accumulation and failure. damage in composites may violate the translational symmetry of even initially periodic structures and hence, the analysis of non-periodic structures becomes particularly relevant in the context of assessment of damaged material. the suggested approach is not constrained by the requirements of a representative volume and hence there is a larger freedom in selecting the volume of considerations at the structural scale. it enables simpler and more efficient modelling of deformation in damaged material. this was demonstrated for layered textile composites prone to failure through the delamination mode.   
  
further work and synergy with the parallel projects  
the intercom project created a densely cross-linked cluster of studies leading to the experimentally proven, verified multi-scale concept. a number of approaches and techniques developed within intercom expanded the capabilities of numerical analysis and the design of novel composites which has been developed by the pi and collaborators in a number of parallel projects. these tools allowed simulating and analysing new patterned graded and functionalised composites manufactured by means of liquid resin print method. the methods developed within intercom will be further exploited and applied to the design materials at the local scale to enhance composite performance at the component level.   
  
conclusion  
the intercom project facilitated and helped the reintegration of the pi in the new institution. it made a pronounced contribution in establishing a new research niche and allowed to build on the research work initiated previously.

# BIOTIC

Project Acronym: BIOTIC

programme & topic: FP7-PEOPLE PEOPLE-2007-2-1.IEF

Most frequent returning words in objectives:

* ('textile', 15)
* ('materials', 14)
* ('textiles', 8)
* ('functionalities', 7)
* ('biotechnology', 7)
* ('research', 7)
* ('surface', 6)
* ('industry', 4)
* ('properties', 4)
* ('production', 4)
* ('enzymes', 4)
* ('development', 4)
* ('modification', 4)
* ('applications', 3)
* ('chemical', 3)
* ('knowledge', 3)
* ('processes', 3)
* ('fibres', 3)
* ('surfaces', 3)
* ('novel', 3)
* ('technologies', 3)
* ('functionalisation', 3)
* ('products', 2)
* ('enzyme', 2)

textile materials are extremely versatile materials, combining different materials and structures for a wide range of applications. besides the well known applications, textiles are used in medical applications, e.g. wound treatment, sensors, artificial aortas and vascular grafts, but are also used abundantly in sport, vehicles, geo-textiles, aircraft, construction, agriculture, protection, defence, transport, packing/storage and chemical industry. the european textile industry is typically in a transformation from labour intensive products to knowledge intensive products and therefore the textile industry has a great demand for innovative high-tech materials with special properties and added functionalities, like smart textiles and biomedical textiles.  
  
biotechnology, or more specifically enzyme technology, has enormous potential for the production and synthesis of textile materials with advanced functionalities because of the high specificity of enzymes. the importance and potential of biotechnology in textiles has been assessed in the last years. biocatalysis has already proven to be very profitable in industrial textile pre-treatment processes of natural fibres. application of enzymes is not limited to biological materials, recently it has been demonstrated enzymes are able to modify the surfaces of synthetic textile materials as well. taking into account the current international state of the art, today's scientific challenge is to make the enormous potential of biotechnology for the production and synthesis of textile materials with advanced functionalities an opportunity for the european textile industry.  
  
the development of biotechnologically functionalised (bio-inspired) textile materials requires improved fundamental understanding of the relevant parameters and the development of novel biotechnological production processes for textiles that exhibit the desired functionalities.  
  
the general aim of our research is to functionalise (bio)polymeric textile materials using modern biotechnology. biotechnological surface modification of textile materials involves processing of fibres or (bio)polymers to modify the physical chemical surface properties or the introduction of functional groups on the surface.  
  
the primary research objective of the proposed research was to generate new knowledge and to develop technologies to create textiles with unique surface properties and advanced functionalities using biotechnology. the research focused on:  
- enzymatic modification and functionalisation of pet.  
- chemo-enzymatic surface functionalisation of textile materials.  
- incorporation of biocatalysts into textile fibres.  
  
manipulation of surface characteristics of textile materials is of fundamental importance in the production of advanced functional textiles. while a lot of research focuses on chemical or physical modification of surfaces, the introduction of functionalities using biotechnology is a relatively unexplored and modern scientific area. the advantage of biotechnology or more specifically enzymes over other technologies is their high specificity towards a certain substrate.  
  
the research resulted in new, specific knowledge and technologies to create biotechnologically modified textile materials with unique properties. the research contributes to bio-based economy through the development of novel processes for textiles exhibiting the desired functionalities and through development of novel enzyme technology for modification and functionalisation of surfaces.

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# FIBRA

Project Acronym: FIBRA

programme & topic: FP7-KBBE KBBE.2012.3.1-03

Most frequent returning words in objectives:

* ('crops', 61)
* ('china', 48)
* ('fiber', 44)
* ('fibre', 39)
* ('flax', 33)
* ('hemp', 33)
* ('research', 30)
* ('fibra', 22)
* ('project', 22)
* ('task', 21)
* ('production', 20)
* ('bast', 19)
* ('kenaf', 19)
* ('area', 18)
* ('jute', 17)
* ('cultivation', 16)
* ('europe', 15)
* ('information', 15)
* ('yields', 15)
* ('crop', 14)
* ('products', 14)
* ('ramie', 12)
* ('future', 11)
* ('fibers', 11)

executive summary:  
for thousands years (6000 bc), mankind has been strongly dependent on fibre crops for any kind of purposes (www.ienica.net). during the last two decades, non-textile applications have attracted growing interest by research and industry, with considerable investments in r&d for the reinforcement of existing markets, or to boost innovative markets. fibre crops are and will be the future raw materials not only for the textile industry, but also for eco-friendly building materials, particleboards, insulation boards, cosmetics, medicine and source for other bio-polymers, agro and chemicals.   
interest in natural fibres is also increasing lately due to new environmental legislation and concerns, resulting in a growing market for biodegradable and recyclable materials. total worldwide demand for fibre is predicted to increase from approximately 50 million tonnes/year (1999) to 130 million tonnes/year by 2050.   
according to part of the plant that the fibres can be obtained categorized to bast, leaf, grass, seed hairs, palm and woody fibres (www.fibrecrops.nl). bast fibers contribute an exceedingly small fraction of world textile fibre supply, which is overwhelmingly dominated by cotton. with more than 30 mha, cotton is by far the widest cultivated fibre crop worldwide, corresponding to 80% of the global natural fibre production (fao, 2009). china is a lead country in cotton production (30% of the world production) and eu provides only 1.2% (fao, 2009).   
bast fibres currently represent only 16% (approx. 4 mt.) of the global production of natural fibres, whose only 6% is produced in europe. conversely, more than one sixth of the global production is supplied by china (fao, 2009). flax is by far the most important bast fibre crop accounting for almost 40% and 77% of the total bast fibres in china and europe, respectively, while hemp represents only 7% and 3%.  
eu and china are both major players in the field of fibre crops. in europe the major fibre crops are cotton, hemp and flax, while in china, bast fibres are the ones with the highest importance (flax, kenaf, ramie and jute). along with bast fibre crops, high yielding crops like miscanthus, giant reed, switchgrass and bamboo are alternative and innovative fibre crops. whether their fibres quality is lower than that of bast fibres, the high productivity associated with a low energy requirement, could make them interesting feedstocks for papermaking, bio-building or biopolymers, and bioenergy purposes.   
in the light of a strong renewed interest in fibre crops and sustainable biobased production chains as well as the relevant research activity on fibre crops carried out from both counterpartsâ, a sound link between eu and china (through fibra project) led to a wider stakeholdersâ participation. finally, fibra provided a long term vision on future and common research activities between eu and the republic of china.  
fibra project was funded from both eu (dg research) and china (caas â chinese academy for agricultural sciences) and in the framework of this project a high number of events had been carried out (thematic workshops, summer schools, conferences, twinning events, etc.). the experienced fibra consortium and the high quality events that were organised resulted in the collection of important information of fiber crops that presented on both project deliverables and reports and project website (reports, presentations, etc.). moreover, fibra improved the exchange of information between europe and china that will continue beyond the project end.  
  
project context and objectives:  
fibra project is a support and coordination action project and had as main target to link the research activities carried out on both eu and china and to provide a long term vision on future common research activities on fibre crops in order to improve researchersâ training opportunities.  
the specific project objectives were:   
1. to develop a resource efficient system via optimisation of raw material from fibre crops for multiple uses (crops breeding, crops agronomy, logistics, integrated assessment) (wp1)  
2. to support the biorefinery concept for processing fibre crops (wp2)  
3. to facilitate future collaborations between european and chinese industries in the field of fibre crops and bio-based products (wp2, wp3, wp4, wp6, wp7)  
4. to ensure a wide-range networking of the relevant scientific communities and stakeholders and the systematic establishment of linkages such as broad networking (wp3) twinning of large sets of research projects and consortia (wp4) and short exchange /visits of researchers and summer schools (wp5)  
5. to improve training opportunities in the area of fiber crops to european and chinese scientists (wp5)  
6. to provide a long term vision on future common research activities that will contribute to the international policies of the eu (wp6)  
7. to disseminate the project results (wp7)  
the work that had been done in each work package in order the specific objectives of the project to be fulfilled is presented below.  
 to develop (update) a resource efficient system via optimisation of fibre crops raw material for multiple uses (crops breeding, crops agronomy, logistics, integrated assessment) (wp1)   
in wp1 entitled âfibre crops optimisation for multiple usesâ three tasks have been planned. the first task focused on genetics and genomics, the second task on ecological adaptation and agricultural practices and the third on harvesting, processing and logistics of the fibre crops in both eu and china. in all tasks the collected information was based on recently completed and/or on-going research eu research programmes (eu framework programmes and eu member statesâ national programmes), on chinese research projects (mainly funded by the chinese academy of agricultural sciences â caas) as well as on international literature (studies, articles, books, etc.).   
it should be pointed out that quite important information of fiber crops optimisation was collected from the first and the second thematic workshops that took place in rome (march 2013) and in poznan (june 2014) as well as from the three summer school (july 2013, july 2014 and july 2015).   
 to develop effective production chains (update) for fibre crops following to the biorefinery concept (wp2) (m27-39)  
  
in wp2 entitled âbiorefinery production chain of fibre cropsâ the work has been organized in three tasks. task 2.1 was dealing with the products that can be derived from the fibre crops (fiber-based, green chemicals, compounds, composite and energy products), task 2.2 was dealing with the existing or emerging markets and task 2.3 with the socio-economic and environmental issues in relation to the production of fibre crops. in all tasks the collected information was based on recently completed and/or on-going research eu research programmes (eu framework programmes and eu member statesâ national programmes), on chinese research projects (mainly funded by the chinese academy of agricultural sciences â caas) as well as on international literature (studies, articles, books, etc.).   
it should be pointed out that quite important information on the development of an effective production chain was collected from the third thematic workshop that took place in helsinki (march 2015), from the three summer school (july 2013, july 2014 and july 2015) as well as from the two twinning events (october 2013 & july 2015). the information that was collected from all these events was taken into consideration in the final formation of the deliverable of second work package.   
  
 to facilitate future collaborations between european and chinese industries in the field of fibre crops and bio-based products (wp2, wp3, wp4, wp6, wp7) (m27-m39)  
this objective was accomplished through in five work packages of fibra.   
in wp2 (task 2.1 and 2.2) the markets and the products of the fibers crops in both sides were recorded (two companies from fibra consortium and one from chinese advisory board were strongly contributed on that). in wp3 it was achieved through the thematic workshops (the third one was organised in the third reporting period, task 3.1), in wp4 through the large set twinning events (the second one was held in beijing in month 35), in wp6 through the long term vision and targeted dissemination actions to the relevant stakeholders (wp7). apart from the fibra network, the chinese mirror group supported by caas was strongly facilitated the future collaborations between eu and chinese industries.  
 to ensure a wide-range networking of the relevant scientific communities and stakeholders and the systematic establishment of linkages such as broad networking (wp3) twinning of large sets of research projects and consortia (wp4) and short exchange /visits of researchers and summer schools (wp5) (m27-39)  
this specific objective was dealt through three work packages wp3, wp4 and wp5. in wp3 the broad fibra networking will be achieved through three key thematic workshops (one of them was carried out in month 30, task 3.1), videos that were produced and were highlighted the basic topics and findings as well as posters and leaflets distribution (task 3.2). the themes of the workshops were: genetics and genomics of fibre crops (second reporting period), agronomy and logistics (first reporting period) and fibre crops in a biorefinery concept (third reporting period). the presentations that were made as well as the discussion that took place in round tables discussion were consolidated in fact sheets. in wp4 the wide-range networking was ensured through the organisation of two large set of twinning events (one in europe and one in china) in which current projects coordinators were invited to make presentations and to deliver a feedback report after each twinning event (task 4.1). additionally, in task 4.2 exchange of information (data, material, methods, protocols, etc.) were organized after each twinning event (task 4.2). in wp5 the wide-range networking was carried through the organisation of three summer schools; two in europe (catania-italy & lisbon-portugal) and one in china (beijing) (task 5.1).   
 to improve training opportunities in the area of fiber crops to european and chinese scientists (wp5) (m27-m39)  
the training opportunities of the european and chinese scientists on fibre crops were improved through wp5. this was done through the three summer schools (task 5.1) as well as through the training courses and exchanges of researchers that were organised in task 5.2. through the three summer schools a number of exchanges of researchers were supported.   
 to provide a long term vision on future common research activities that will contribute to the international policies of the eu (wp6) (m27-39)  
the high level information that was collected and evaluated by: a) the fibra consortium and the advisory board both having outstanding expertise on fibre crops and b) the wide coordination activities through the workshops, twinning set events, exchange and training opportunities of researchers and fibra conference build the long term vision of fibre crops on future research activities in eu and china (wp6) that included wider industrial participation and improved training opportunities of researchers. all gathered information from fibraâs wps was further analysed and articulated in a comprehensive critical review aimed at: i) pinpointing major bottlenecks and possible solutions for fibre crops development (task 6.1), and ii) drawing scenarios for long-term joint research actions and programmes on fibre crops between eu and china (task 6.2). a science- and policy-based consultation with the honorable members of the advisory board and the chinese mirror group gave more confidence in scenarios for the future being on the right track.  
 to disseminate the project results (wp7) (m27-m39)  
the fibra results were disseminated in wp7. in task 7.1 a whole dissemination plan was created (it was included articles in journals, conferences, link with relevant projects and organisations, etc.) that was presented in the kick-off meeting and was updated on yearly basis. a fibra conference with title âboosting market share of fibre crops between eu and china: a roadmap for enhancing trade relationsâ had been scheduled at the end of the project (task 7.2). in task 7.3 a website for fibra was created (www.fibrafp7.net) that contained all the project deliverables as well as a restrict members area (task 7.3).  
  
project results:  
fibra provides information on the whole production chain including breeding, agronomy, harvesting & logistics of the bast fiber crops. furthermore, information on products and markets has been presented and analysed. the environmental implications had been critically analysed as well as their sustainability. in the last part of the project the bottlenecks have been detected and possible solutions had been proposed. finally, a comprehensive review for a long-term vision on futures cooperation activities between eu and china in the area of natural fibres has been proposed. throughout the project lifetime important information had been collected through the projectâs events namely thematic workshops, matchmaking twinning events, summer schools, conferences, national workshop, etc. and this information was analysed in the projectâs deliverables.  
  
breeding of the fibre crops  
  
hemp: the historical importance of hemp cultivation in europe is well reflected by the abundance of cultivars, traditional landraces, and populations that were selected in the main areas of hemp cultivation throughout europe. mass selection was used in the past to select the most important cultivars, such as carmagnola in italy or novosasdka konoplia in yugoslavia. in mass selection pollination cannot be controlled and any improvement in fiber content is very slow. in 2004, the number of registered hemp cultivars increased to 45, in 2008 the list contained 46 industrial hemp cultivars and currently the number of cultivars registered for the eu is 51 reflecting the increased interest in the crop.   
according to archeological finds and ancient records, it has been more than 6000 years since china started cultivating hemp for fiber and seed. due to the long history of cultivation and the wide spread of this fiber crop throughout different geographic zones of climate in china (latitude range about 23â50âºn), hundreds of hemp landraces have been established. large collections of germplasm resources have been collected and maintained in the yunnan academy of agricultural sciences, which comprise approximately 350 accessions with a good representation of fiber/seed hemp groups. in 1970s, several cultivars were developed and, although rarely, some are still used in production now. from the 70s till the end of the 20th century limited research on hemp breeding was carried out. in the past decade, many new applications for hemp biomass have arisen and they have been accompanied with the development of related industries and an increase in hemp cultivation area in china. since 2007, hemp breeding research has continuously received financial support from china agriculture research system, and five industrial hemp cultivars (yunma 1, yunma 2, yunma 3, yunma 4, yunma5) have been bred and widely cultivated in china. other hemp cultivars (longdama 1, jinma 1, wangdama 1, wangdama 2) have been registered and used in certain provinces.  
flax: flax, being an ancient crop, has performed a significant role throughout human history. the principal use of flax was industrial, manufacturing textiles from fiber and paints and varnishes from oil. however, in the last decades decline in flax cultivation has been observed. nevertheless, recently the renewed interest in flax products has been noticed. this is due to research findings suggesting that the flax raw material provides a variety of industrial and health benefits. flax oil is characterized by high content of linolenicacid (-3 group) increasingly used as a human diet supplement protecting against atherosclerosis. flax fiber gains more and more applications, like in the automobile and construction industries as recyclable composite material. unique flax fibers are equipped, by genetic engineering, with polyhydroxybutyrate (phb) since they are compatible with synthetic polymers (polypropylene and polystyrene) and facilitate their biodegradability. the phb-fiber embedded in polylactide may also serve as a scaffold for tissue engineering and has been shown to be useful as biodegradable implant. the soluble and insoluble fibers are becoming increasingly used in human nutrition. according to the experimental data found in the literature, the changes in the gene expression can lead to cell wall structure alterations in various plant species. the modifications aimed at genes from different fibrous species have been based on the knowledge about the mechanism of cell wall formation in model plant species (e.g. arabidopsis, poplar, tobacco). considering the genomic data (flax genome sequence) the genes encoding transcription factors that control cell wall polymer biosynthesis are also among the potential targets for genetic manipulations. as biological and genomic information is widely available, researchers can use diverse biotechnological approaches in order to enhance the quality of flax fibers. fiber structure can be the subject to modifications by employing either conventional or genetic engineering approaches, by manipulating the native polymers or by introducing novel polymeric compounds, as shown in a number of scientific publications. for example, numerous studies have emphasized the role of lignin biosynthesis genes in controlling the secondary cell wall formation. in other studies, it is reported that the stem tissue targeted phb biosyn-thesis strongly affects fiber content and mechanical properties. new approach for flax modification with the use of oligonucleotides that remodel targeted gene methylation and thus gene expression and finally plant improvement is reported. it can be concluded that classical breeding methods supported by genetic engineering technology can accelerate the breeding efficiency for improved yield and quality ofânewâ flax.  
  
agronomy and importance of the bast fiber crops   
  
bast fibre crops are considered the most important group worldwide. of the bast fibre crops, flax and hemp are the most interesting for the european countries, while in china ramie, jute and kenaf are also major crops and are being supported by significant research activity in breeding and agronomy. ramie is the crop that is being cultivated in the largest area in china (80,000 ha), among the other bast fiber crops. the kenaf cultivation in china is date back to almost one century. over the last 20 years, the total planting area of combined kenaf/jute in china ranks the third in the world next to india and bangladesh, together representing more than 90% of the total kenaf area. average annual planting area in china (2010/11) was less than 100,000 ha, reaching a peak of over 900,000 ha in 1985. kenaf production has been declining in the last years due to the strong competition by synthetic materials.   
the main producers of flax worldwide are: eu, belarus, russian federation and china. in europe (2012) the main producers are: france (52,400 tons), uk (13,825 tons), the netherlands (13,290 tons) and belgium (10,000 tons). in figure 6 presented the area of cultivation of fibre flax worldwide. the area of fiber flax cultivation in china has been sharply decreased to 10,000 ha in the last two years, while the area of linseed cultivation is around 600,000 ha. a first estimation for 2015 showed that its area of cultivation of hemp has been increased to 25,000 ha from 18,000 ha in 2014. the main producer in europe is france. it should be pointed that the global area of cultivation is 80,000 ha (2011).   
fibre flax is an annual crop that needs at least 600-650 mm annual precipitation and 110-150 should be occurred in the vegetation phase. it requires fertile, medium-heavy soil, particularly humus sandy clay soils with ph 6.5-6.9. in poland had been found that the best crops before flax in rotation are cereals, especially oats. the sowing time is few days after oats (soil temperature 7 - 8 0c). 11-14 t/ha seeds are required for fiber flax and 5-7 t/ha for linseed. the sowing should be done in rows 8-12 cm and 2 cm depth. it requires 20 kg n/ha, 60-80 kg p205 and 120 kg k20 (n-p-k â¡ 1:2:3). in figure 8 presented the yields of fiber flax in the main european producersâ countries. the straw yields varied from 0.9 to 7 t/ha, while the seeds yields from 390 to 930 kg/ha. the achieved yields of flax in europe came up to 70% of the potential fibre and seed yields. the mean yields in china are 6.5 t/ha. at present, the planting area of flax is about 10,000 ha, which is mainly distributed in xinjiang, heilongjiang and yunnan province.  
hemp is a short-day plant that has great adaptability to climate conditions and it does not require pesticides or irrigation water. it has a rapid grow and in 100 days can reach a height of 4 m and its moderate yields can be 10 t/ha. its consumption of fertilizers or irrigation is modest and hemp crops suppress weeds and some soil-borne diseases and at the end of its cultivation the soil condition is healthier and improved. it is considered a good forecrop for cereals cultivation. hemp absorbs heavy metals such as cd, pb, zn, cu, contribute to the recultivation of contaminated soils. it could be a plant for recultivation. it is considered that has relative resistance to periodic water shortage. the planting density for textile uses should varied from 100 to 200 plants per square meter. due to its rapid growth, hemp requires substantial available nutrients (n-p-k) to produce high biomass yields (> 100 kg n/ha).  
in china a large number of varieties have been developed with increased yields and increased resistance to diseases. currently, china produces 40% of the total hemp production (12,809 ha; faostat, 2013). industrial hemp in china is being cultivated either for its seeds and/or for its fibrous stems. currently, the research on industrial hemp in china is focused on optimization of agricultural practices with emphasis on mechanical harvesting.   
kenaf (hibiscus cannabinus l.), originated from africa, was introduced in china in the beginning of 20th century reaching it highest planting area in 1980âs. in europe the research started in 1990s as non-food crop for biobased products and bioenergy. kenaf according to their reaction to flowering are divided in two groups the early and the late-maturity varieties. the soil temperature should be at least 150c and the sowing depth should be from 1.5 to 2.5 cm. kenaf is a self-thinning crop and reduces its population during the growing season. it is cultivated at high plant populations, ranging from 300,000 to 500,000 plants/ha. a total quantity from 8 to 15 kg seeds/ha it is required for sowing. it has been estimated that when kenaf gave 10 t/ha yield the fertilization was: phosphorus: 30 kg n/ha, sulfur: 30 kg n/ha, potassium: 50 kg n/ha, nitrogen 230 kg/ha and copper: 3 kg/ha. 500 â 625 mm rainfall over a period of 5 to 6 months is needed for a successful production of kenaf fiber. because the crop hosts the root-knot nematodes crops that are sensitive to these should be avoid following kenaf cultivation such as cotton and peanut. crops such as groundnut, rice, maize and sesame are good choice to follow kenaf. the sowing should be done from end of april till beginning of may. the harvesting should be done from middle of october till mid of december depending on the final use. dry stem yields 10-15 t/ha have been recorded in experimental fields in south eu.  
it should be pointed out that high yielding varieties have been developed in china such as h328 and h386. in figure 15 presented an experimental field with kenaf (variety: h328) at harvesting time and plants that were about 7 meters high. it has been reported (ibfc, fibra project) that these new kenaf varieties can give yields up to 7,500kg fiber/ha (30 ton dry stalk /ha). in the view of fibra project two kenaf varieties from china (h328 & h368) were tested in greece by cres and the achieved yields were high and quite comparable to the commercial kenaf varieties imported from usa.  
jute (corchorus capsularis l.) is considered a quite important fiber crop next to cotton. it is known as known as the "golden fiber" and/or "soft fiber". jute represents the 70% of the global production of bast fiber crops. it accounts for 70% production of global bast fiber crops. china is the third largest area of jute cultivation in the world, and the suitable area for jute plantation in china is from 190 to 320 n.   
jute seed can be sowed when the temperature of soil reaches 15 or 16 0c, from late april to early may in south of china. the suitable plant density should be about 200,000 plants per ha. jute is not tolerant to drought, and it demands much fertilization and moisture, so the farmland with good irrigation condition is suitable for planting jute. in order to get potential high yield, the deep and soft sandy loam soil with strong fertility and water holding capacity should be used to plant jute. jute is a fiber crop with high yield and high growing speed, which need much fertilization and water. jute is sensitive to nitrogen and potassium, while not sensitive to phosphorus. 3.5kg to 4.6kg nitrogen, 1.2kg to 2.3kg phosphorus and 5.9kg to 13.0kg potassium are required when produce each 100kg raw fiber. potassium demand is twice or three times higher of nitrogen and five or six times of phosphorus.  
there are some elite jute varieties planted in china, such as meifeng no.4, jute 179, fuhuangma no.3, zhonghuangma no.1, no.2, and fujute 1, 2, 3 (figure 16) and yueyuan no.5. the average raw fiber yield of new elite varieties can reach 7500 kg per ha, while the fine fiber yield can reach 4000 kg per ha.  
in the view of fibra project a total number of four jute varieties were tested in greece for a period of two subsequent years and the growth and yields were quite high and quite similar to the yields recorded from the kenaf trials that had been established next to jute.  
ramie (boehmeria nivea l.) is commonly known as china grass that can be harvested from 3 to 6 times a year. it is originated most probably from china and it grows as a shrub up to 2.0 -3.5 meters tall (figure 19), with dark green, heart-shaped, crinkly leaves. it is considered extremely absorbent, much more than cotton, ramie fabric breathes well and makes comfortable clothing for warm and humid summers. ramie is one of the strongest natural fibers and it is strong even when wet. like linen, it will break if folded repeatedly in the same place.   
ramie is a perennial crop (6 to 20 years), which has strong root system, providing it with powerful fertilizer absorption ability. ramie has the ability to sprout from stem cuttings (figure 18). the biological mass of stem and leaf of ramie is huge, so large amount of fertilizer is essential for higher yield production. among all of them, nitrogen is one of the most important. the most suitable climate for ramie is one which is warm and humid with an annual rainfall (or irrigation) of at least 1000 mm, evenly spread over the year. ramie is tolerant of a range of soil types but is reported to be sensitive to waterlogging. well established plants can tolerate moderate drought and frost but grow better where these are absent.  
the dry weight of raw stem fiber ranges from 3.4 to 4.5 t/ha/year. with yields 4.5 t/ha/year dry raw fiber 1.6 t/ha/year of dry non-de-gummed fiber can be obtained. during the de-gumming process weight loss up to 25% can be expected and thus from 1.6 t/ha/year of dry non-de-gummed fiber up to 1.2 t/ha/year of de-gummed fiber can be produced.  
  
harvesting & logistics  
  
until 1960s hemp was largely cropped in europe. at that time harvesting and fiber extraction were often done manually. during the industrialization period this heavy job was abandoned except in areas where the mechanization was not developed. in china, except in some cases, bast fiber crops are still harvested manually as is the fiber extraction. as industrialization and development are increasing in chinese rural areas, fiber crops are being abandoned. therefore, there is a need to develop an appropriate harvesting and logistic system for bast fiber crops in china.   
the study through fibra has shown the current mechanical harvesting systems utilized for common bast fiber crops and the innovations, as commercial machines and prototypes, which have been designed to improve the harvesting chain. referring to flax, the high industrial demand for fibers in the20th century led to develop technologically advanced and efficient machines and processing facilities. these machines, during time, were improved until present day to obtain high-quality fibers; this determines the success of the entire industrial chain.   
nowadays, the technological level of flax harvesting systems may be considered advanced enough to fully exploit the crop. in fact, with the introduction of combined harvesting systems, it became possible to harvest seeds and uniformly retted stems at the same time. how-ever, it is important to stress that scientific evidences based on machinery tests of combined harvesting systems are still needed to confirm the efficacy of the innovation.   
referring to hemp, the introduction of industrial cultivation of monoecious plants in the 1960s created new possibilities for harvest mechanization. this is because monoecious hemp, unlike the dioecious varieties, is characterized by all plants maturing at the same time, and is more uniform in fiber content and quality. however, compared to flax, the minor success of hemp can be ascribed to different factors. problems are mainly linked to the inefficiency of the processing lines present in europe and the lack of machines capable to furnish high-quality fibers for textiles. therefore, the initial idea was to adapt flax machines and processing facilities to hemp. this possibility was successfully demonstrated just in part by the engineering unit of the agri-cultural research council (cra-ing) through trials carried out in france using flax turners, balers, and processing lines. the tests showed that hemp stem sections of 1 m could be potentially turned, baled, and processed with flax machines, but the lack of mower capable to create stem sections of 1 m had impeded the completion of the harvesting chain. another gap in the mechanical harvesting of hemp was the lack of combined harvesting machines. however, with the recent innovative machines developed by the company hemp-flax and by the institute of natural fibers and medicinal plants in poznan, it has been possible to address this challenge.   
in the light of a strong renewed interest in fiber crops and sustainable bio-based production chains, the need of mutual exchange of relevant research activity on fiber crops carried out in the eu and china is highly recommended. in order to foster the collaboration, the fibra project was funded by the eu with a wide stakeholdersâ participation and the aim of providing a long-term vision on future and common research activities between the eu and the republic of china. for this reason, fibra has furnished a view of the common harvesting systems that exists in europe and in china for flax, hemp, and kenaf, focusing on the innovations that have been recently applied in mechanical harvesting systems to improve the chain and to ensure the production of high-quality fibers. other machines capable to perform successfully the combined harvesting of seeds and fiber were presented as well. however, the study has also highlighted that research gaps in harvesting technology remains for combined harvesting of kenaf. furthermore, today other bast fiber crops such as nettle, ramie, and jute are receiving a lot of attention, but the mechanical harvesting systems for these crops are still limited. therefore, further effort in the research should be focused also toward the identification of mechanical systems for these crops.  
  
products from fiber crops  
  
various fibre crops are currently being used for the manufacture of different types of products. some of these represent well-established traditional products, whereas a good number of new types of products are under keen development and thus entering the markets. in this review, an overview is given on the current main products and emerging new products, ...

# MULTITEXCO

Project Acronym: MULTITEXCO

programme & topic: FP7-SME SME-2013-2

Most frequent returning words in objectives:

* ('textiles', 38)
* ('structures', 34)
* ('project', 32)
* ('textile', 30)
* ('multifunctional', 29)
* ('monitoring', 29)
* ('masonry', 29)
* ('applications', 26)
* ('multitexco', 24)
* ('application', 24)
* ('tensile', 21)
* ('construction', 20)
* ('test', 20)
* ('system', 18)
* ('reinforcement', 17)
* ('order', 17)
* ('sensor', 16)
* ('performance', 15)
* ('methods', 14)
* ('sector', 13)
* ('relevant', 13)
* ('products', 13)
* ('systems', 13)
* ('evaluation', 13)

executive summary:  
the multitexco project goal was to scientifically and technologically characterize the latest achievements in multifunctional technical textiles, allowing the definition of guidelines and best practices for their optimal use in the construction industry and hence supporting the smes involved in the sector to fully exploit the potential of such materials.  
textile materials are widely used in construction, where the recent catastrophic events (e.g. the earthquakes that struck italy in 2012 and 2016) highlighted the need of efficient methods and technologies for both retrofitting and structural monitoring. in the last decade, considerable boost in the development of advanced textiles has been provided by a number of research and innovation projects, addressing in particular the construction sector.   
however, despite the benefits and potentials demonstrated by these projects, the market uptake of such solutions is still not as wide as expected, mainly due to some issues still partially unsolved: the non-availability of tests methods for multifunctional textiles to provide certifications, the lack of quantification models especially for reinforcing textiles, the lack in codes and standards and finally the need for a knowledge transfer to companies in the construction sector to foster the practical adoption of these materials. indeed, many building practitioners are still unfamiliar with the behavior and the characteristics of these technical textiles. shortage of information to the design and construction community about use and properties of these materials heavily limits their exploitation potential and consequently their practical adoption.   
in this framework, the aim of multitexco was to support the competitiveness of the european smes of the construction and technical textile sectors by addressing the above mentioned needs by means of the development of scientific knowledge, testing procedures, guidelines and pre-normative research, enabling future standards at eu level to support smes to fully exploit the new generation of multifunctional technical textiles in a more efficient, effective and profitable way. the following application fields have been targeted by the project: masonry seismic reinforcement, geotechnical applications and tensile structures.   
actually, examples of multifunctional textiles for the construction sector comprise textile based structures used for the rehabilitation of buildings, providing both strengthening and monitoring functions, geotextiles for the stabilization and monitoring of soil structures such as railway or roadway embankments and high performance technical textiles for tensile structures for covering large areas such as stadiums or exhibition areas to name a few.  
the ambitious multitexco goal was far away to be achieved by the capability of a single sme and required a collective r&d effort led by sme associations at european and national level. the project addressed the needs of the sme members of 5 associations throughout eu to access to the newly developed smart textiles in a more efficient, effective and profitable way. the project was coordinated by texclubtec, the italian association of technical textiles, and included in the consortium also the belgian association unitex, the association clutex (czech republic) as well as the roofing association catider (turkey) and vpi (germany). moreover, the project included three smes, selcom (italy), arimeks (turkey) and maco technology (italy) and four rtd performers entrusted to carry out the research activities in the frame of the project: dâappolonia (italy), karlsruhe institute of technology (germany), acciona (spain) and centexbel (belgium).   
key objectives of the multitexco partners were the development and characterization of :  
-multifunctional textiles for masonry application having both reinforcement and monitoring capabilities  
-sensor embedded geotextile structures  
-sensorized textile membranes for tensile structures  
project context and objectives:  
the overall objective of multitexco project was the scientific and technological characterization of the latest achievements in multifunctional technical textiles in order to pave the way to the market uptake of these solutions. actually, textile materials are widely used in construction in both ground and building structures. unreinforced masonry structures are highly vulnerable because, being originally designed mainly for gravity loads, they often cannot withstand the dynamic horizontal loads in case of strong earthquakes. soil structures, such as embankments, are subjected to landslides after heavy rainfalls or during earthquakes, as witnessed by the recent tragic events in italy. hence, the necessity of efficient methods and technologies for the retrofitting of existing buildings and earthworks and for the related monitoring to possibly prevent the structural damage is clearly evident. examples of advanced composites for the construction sector comprise textile-based structures used for buildings rehabilitation or seismic upgrading, geotextiles used for the stabilisation of soil structures, such as railway or roadway embankments, while high performance technical textiles are used for tensile structures covering large areas, such as stadiums or exhibition areas. in all such applications, the novel textile materials potentially offer a brand new functionality in addition to the main functions of the standard technical textiles, namely the possibility of monitoring the structural health of the reinforced structure. the health state of a building or earthwork can be assessed through the use of structural health monitoring (shm) techniques at different stages of the construction life, namely construction, inspection, operation, dismantling. moreover, measurements can be carried out after a severely damaging event (for instance an earthquake), in order to assess the state of the structure and its remaining service life. measurements over time can be used to track changes in structural performance, addressing repair actions when appropriate. despite the above-mentioned benefits, many building practitioners are still unfamiliar with the behaviour and the characteristics of these materials. shortage of information to the design and construction community about use and properties (mainly long-term behaviour) of these materials limits their exploitation potential and consequently their practical adoption. moreover, as these high innovative solutions are derived either from modification of existing materials or from newly developed high performance textile materials, in general new codes, specifications, guidelines and standard test methods are required for the purpose of their design, use, testing and certification.  
in this context, multitexco aimed at the definition of tests methods, guidelines and best practices though pre-normative research in order to enable the development of future standards able to favor the wide use of the new generation of multifunctional textiles for the construction sector. the specific target applications of multitexco were:  
â¢ masonry seismic reinforcement and monitoring  
â¢ geotechnical applications  
â¢ tensile structures  
in particular, the following main objectives were expected to be achieved by the project:  
1) the identification and characterization of relevant existing and newly developed products by means of extensive scientific characterization, laboratory work and field tests, leading to define design and application procedures. a complete characterization under laboratory as well as under working conditions in simulated harsh environments were expected in order to assess the specific performances of the different multifunctional textiles investigated.  
2) the delivery of a sound scientific basis for the new generation of multifunctional textiles in order to favor the standardization process at the eu level also by means of a close link with the standardization bodies.  
3) the delivery of a knowledge management platform to be provided to the sme-ags as proprietary tool transferring them the project results and including:  
- the knowledge repository, gathering the technical specifications and information about the new advanced technical textiles, detailing their functions, features, costs, application procedures etc;  
- the customization support tool, enabling the users to select the most suitable solutions and products for each specific targeted sector (masonry seismic reinforcement, geotextiles, tensile structures) according to intervention type, specific application scenario, conditions, location and cost target, providing all the information about application procedures and performances.  
- the e-learning modules, providing smes with a tool able to train the end users and the smes members of the multitexco associations on using the new technologies.   
the knowledge management platform allows accelerating the introduction in the market of the new products in each specific application sector by facilitating their dissemination, demonstration and by supporting the smes through training activities. in addition, the testing procedures, the case studies, and the platform itself will provide smes with a mechanism to develop and promote their own products. moreover, the definition of application guidelines and testing methods, addressed by the multitexco project as pre-normative research, will provide significant inputs for the development/improvement of standards and for the certification of the new advanced textile materials, including new sensors and structures.  
4) a complete lca and lcc analysis allowing verifying the impact of the new technologies on the environment, as well as providing a sustainability comparison of existing solutions with the new products and procedures. the lcc allows evaluating the impact of the new products from an economic point of view in a whole lifecycle perspective, taking also into account the actual cost for the maintenance and repairing of buildings and other target structures.  
all the above-mentioned objectives have been fully achieved by the project.   
  
project results:  
multitexco focused its activity on the following target applications:  
â¢ masonry seismic reinforcement and monitoring  
â¢ geotechnical applications  
â¢ tensile structures  
at the beginning of the project, a review of the state of the art technologies and procedures applied for technical textiles, as well as the relevant standards, has been delivered for each target application. moreover, a comprehensive market analysis for the related applications has been provided, together with an inventory of all the relevant rules, standards and policies at national and international level.   
one of the main areas of investigation in the frame of technical textiles for the construction sector, in the last decade, has been the one related to the retrofitting of existing masonry walls with smart textiles for the rehabilitation of buildings and providing both strengthening in case of earthquakes as well as monitoring functions (shm). an accurate literature analysis has been carried out in order to identify the relevant advancement in this area.   
the analysis was performed at three different levels:   
â¢ relevant r&d projects  
â¢ optical fibers   
â¢ products on the market  
between the relevant r&d projects identified, it is worth to mention:   
â¢ polytect project  
â¢ polymast initiative   
â¢ insysm project  
in particular, the fp6 large-scale collaborative project polytect for small and medium enterprises (smes) ended in the 2010 pushed the state of the art for technical textiles through the development of large area sensor-embedded multifunctional textiles (seismic wallpaper) employing fiber optic sensors for masonry applications. the composite seismic wallpaper has been conceived as a full-coverage or wide-area reinforcing solution for unreinforced masonry buildings and structures. concerning the preliminary analysis on optical fibers, the study has been mainly focused on:   
â¢ polymer optical fiber (pof)   
â¢ optical physical fbg sensors  
an overview was then carried out on each of the two fiber types. in particular, regarding pof sensing, the focus has been on the following aspects:  
â¢ type of pof used  
â¢ sensor type  
â¢ strain resolution  
â¢ dynamic range  
â¢ relative sensor cost  
â¢ relative equipment cost  
â¢ key features & remarks  
regarding fbgs, after the investigation about fbg principle and specifications, the measurement topology allowing sensors multiplexing on a fibre thanks to the use of different wavelengths was analyzed. special attention has been paid on the possibility of directly embroider the fbg sensor optical fiber directly on the textile. in particular, the focus has been on the possible impact on the structural integrity of both the optical sensor fiber and the glass/carbon textile during the whole integration process of the fbg through embroidery.   
then it has been decided do not limit exclusively the analysis to pof and fbg sensors and in order to select the best solutions to be implemented in multitexco, the investigation about optical fibers has been therefore fully completed by classify them according to the following:  
- core material type;  
- spatial disposition of measures;  
- sensing technique.  
according to each of the above criteria, the main typologies can be pointed out as in the following (focus has been mainly given to commercially available solutions allowing long measuring range).  
core material type:   
- polymeric optic fiber (pof)   
- glass (silica)optic fiber (gof)  
  
spatial distribution of measures:  
- discrete (short-gage and long-gage)  
- quasi-distributed  
- distributed  
  
sensing technique:  
- grating-based (fbg, lpg)  
- raman scattering  
- brillouin scattering  
- rayleigh scattering   
- fabry-perot (intrinsic or extrinsic)  
- sofo  
- other techniques  
  
moreover, further distinction can be made:  
- standard telecommunication cable (though properly buffered) or a special cable can be used for sensing  
- single-mode or multi-mode fibers can be used: multi-mode fibers are usually advisable for intensity-based technique, requiring higher signal intensity, though they imply higher attenuation (and then shorter measurable length);  
- intrinsic or extrinsic sensor: in an intrinsic sensor, modulation of the optical signal is a direct result of the physical change in the optical fibre in response to some measurands (e.g. signal change due to the micro- or macro-bending of the fibre); in an extrinsic optical fibre, the signal modulation takes place outside the optical fibre (e.g., signal change due to the changing gap distance between two cleaved fibre surfaces).  
a specific sensor is characterized by a defined set of features, each one describing its characteristics with respect to a certain classification criteria. it is worth pointing out that not all the combinations of the features are possible (ex. point-wise sensors cannot be based on brillouin sensing technique).  
on the basis of this analysis, the optical fibers to be used in multitexco have been selected.   
concerning the technical textile products on the markets, the analysis evidenced that, currently, no products for masonry applications able to both reinforcing and monitoring buildings are present on the market. the commercial systems available on the market can provide only strengthening and retrofitting functionalities (e.g. : rãfix and mapei products).   
  
concerning multifunctional textiles for earthwork, geotextiles have been successfully used in a wide variety of applications for over twenty years in the geotechnical and construction sector. the principal applications include unpaved and paved roadway as well as railway systems, erosion and sediment control systems, subsurface drainage systems, waste containment systems, reinforced soil structures, etc. geotextile reinforced soil structures include steep slopes and embankments over soft soils.  
the state of the art has been analyzed with respect to:  
- relevant r&d projects  
- existing products on the market  
concerning remarkable research projects, the most relevant r&d project with respect to this topic is again polytect, already described with reference to masonry structures, which focused also on earthworks. the solutions developed in the framework of polytect have been based on optical fibers. in polytect project, pof have been investigated as a distributed strain sensor by analyzing the backscatter increase at the strained section using the optical time domain reflectometry (otdr) technique. thanks to their ruggedness, it is possible to directly weave the pof into the textile during the fabrication process and obtain a good and direct force and strain transfer from the textile to the light guiding core of the pof. the textiles not only fulfill the function as a sensor support, they also facilitate the direct transfer of deformations of the structure into measurable strain in the fiber. the strong and the weak point of polytect solutions have been accurately analyzed.   
concerning the products on the market, the following have been investigated:   
â¢ gedise by gloetzl (based on distributed pof sensors)  
â¢ tencate geodetectâ® (based on fbg)  
â¢ must smartgeotex from smartec (based on fbg)   
then an accurate analysis has been carried out in order to identify the most appropriate optical fibers to be used as done also for masonry applications. for the geotechnical application envisaged in multitexco, the most relevant specifications that have been considered were the following:  
- spatial resolution  
- spatial accuracy  
- strain resolution  
- max strain   
- max measurable length  
- max measurement frequency  
  
according to the study, the optical fibers to be used in multitexco have been selected.   
  
as far as the multifunctional textiles for tensile structures are concerned, different solutions for the coating of textile membranes to be used in tensile structures are available at the state of the art and they have been investigated:   
â¢ ptfe â teflon coated fiberglas  
â¢ kynarâ¢ coated membrane/dupont tedlarâ¢ coated membrane  
â¢ acrylic/pet pvc coated membrane  
â¢ high density polyethylene  
â¢ efte foil  
â¢ etc.  
then the focused have been moved on sensing technologies to be embedded in the membranes.  
in the first phase of the project, special attention has been paid in the definition of the requirements of the systems to be developed.   
actually, the multitexco sme associations had a relevant role together with the end users and the rtd performers in order to establish the technological needs and the technical requirements of the new multifunctional technical textiles for each application target of the project. the work has been completed during the first 9 months of the project.  
in this framework, the key features/parameters (as well as the possible sensing technologies) to be investigated in order to characterize the multifunctional textiles enabling their effective use in the construction sector have been defined. in particular, for each target sector of the project (masonry seismic reinforcement, geotextiles and tensile structures) two specific applications have been defined. the parameters to be measured or monitored by using the new generation of multifunctional textiles have been fixed and a selection of possible sensors/sensing technologies to be investigated during the project for the integration in multifunctional textiles has been identified. furthermore, the expected performances to be measured by adequate test methods in the frame of the rtd work packages have been defined.  
as far as multifunctional textiles for masonry seismic reinforcement applications are concerned, since the beginning of the project, one of the scopes has been the definition of the sensing capabilities of the seismic wallpaper for a full coverage of masonry buildings for achieving along the project development the fully characterization of the system. concerning the sensing capabilities, the first objective was the assessment of the building structural status before and after an event (earthquake). two specific applications taking into account the needs of the end users have been defined for the concept of seismic wallpaper aiming at a post-assessment of earthquake event:  
â¢ system to be applied on the internal walls surface of the building for the assessment of structural integrity before and after a seismic event as well as for the seismic certification  
â¢ system to be applied on the external walls surface of the building for the assessment of structural integrity before and after a seismic event as well as for seismic certification  
the starting point for the identification of the parameters to be monitored/measured by the multifunctional textiles for masonry stone and masonry structures taking into account the specific applications defined together with the sme associations and the end-users has been the analysis of the failure modes for the fiber reinforced polymer (frp) used as retrofitting as well as for the masonry. in order to get suitable information and data from the new generation of multifunctional textiles for masonry seismic reinforcement applications, the efforts have been devoted to the identifications of key design parameters in order to plan an intervention after an event.   
as far as the geotechnical application is concerned, a multifunctional geotextile (mfg) is defined a geosynthetic having both stability function and monitoring capabilities. concerning geotechnical applications, one of the main differences with respect to masonry seismic reinforcement applications is related to the fact that natural hazards can be favored by construction activities such as cutting of steep slopes for road or railway purposes which may initiate slope failures. in this framework, the new generation of multifunctional geotextiles could play a relevant role in geotechnical engineering in the mitigation of natural hazards. the application of mfg in geotechnical work can be divided in two specific categories, namely existing geotechnical structures as well as newly built geotechnical structures. one of the typical applications of geosyntethic reinforcement is for constructing embankment over soft soils. in this case, the overall stability of the soil structure is guaranteed by the addition of strong tensile elements in the soil embankments. for embankment of weak or soft soils, the use of high tensile strength geotextile reinforcement could allow for an increase of the design factor of safety. the challenge of maximizing land use in areas where often there are both difficult topographic characteristic as well as difficult soil condition is a relevant objective of designers. specific applications for the multitexco mfg have been considered the ones related to highway or railway embankments. by the analysis of the end users, the 3d rope-like textile structures solution has been considered less relevant with respect to the 2d geotextile structures, which present both monitoring and embankment functionalities.  
as far as the multitexco tensile structure target is concerned, one of the main objectives of the project was the investigation of coating for textile membranes to be used in tensile structures. in particular, specific objective of the project was the characterization of the membranes in terms of ageing, mechanical proprieties and performances. however, since the beginning of the project, both the sme-ags as well as the smes underlined the high potentialities to introduce monitoring functionalities also in the textile membranes. during the requirement phase, the end users indicated as one of the priorities in order to have effective multifunctional textiles for the tensile structures with high market perspectives, the possibility to embed sensing technologies. for this reason, as for the other two target sectors of the project (seismic reinforcement of building and geotextiles), also for tensile structures, two specific applications to be investigated have been selected and the sensing techniques to be embedded as well as the technical requirements have been defined. the discussion during the requirement phase involving the multitexco partners working in the field of tensile structure design and development, underlined a series of challenges. clearly not all can be solved, or the potential solution may not stem from multifunctional fabrics. in tensile structures, a number of parameters require monitoring and easy and reliable sources of data are requested by the end-users. two main target applications have been selected. the highest priority was given to the monitoring of the vibrations in real life conditions of a finished tensile structure and therefore it is identified as first application field. for example fluttering of the fabric, improper pre tensioning and unexpected loads may result in damage and even collapse of a given structure (large area covers, building envelopments, etc.). most attention has been given to the fluttering of fabric. as a second application field, monitoring the abuse or misuse of fabrics was identified. this application may sound bit surprising, but damage claims from the customers to the design engineers may rise very high if it cannot be proven that the construction was used in way that is not covered by warranty. complaints to the manufacturer and designers are frequent in the sector. afterwards, it turned out the end user did not exploit the construction in the advised conditions (e.g. covers for biogas reactors). for these applications, chemical sensing and temperature monitoring devices integrated in (patches attached to) the fabrics were foreseen to be investigated in the framework of multitexco. the monitoring of misuse should be reliable during the entire lifetime of a tensile structure. the sensors will be integrated in final products and will most likely be paid by the developer rather than the customer (although in some application fields it may also be of interest to the customer).the goal is to proof in case of a claim that the fabric was used (or not) correctly, i.e. within the conditions covered by warranty.  
below, the main results for each target application (masonry, geotechnical, tensile structures) have been summarized.  
  
masonry application  
in this framework, the first objective was the definition of multifunctional textile configurations (including the sensor types and topologies) for masonry seismic reinforcement and monitoring, potentially able to respect the requirements described above. in particular, at the beginning, four different preliminary concepts have been conceived: mhm-1 (outdoor), mhm-2 (outdoor), gfp-1 (indoor), gfp-2 (indoor).   
then the project focused its attention on the development of two systems:  
â¢ system for outdoor application (mhm): mortar embedded multiaxial, hybrid glass fiber textile including optical fibers which requires masonry without plaster  
â¢ system for indoor application (gfp): bi-axial glass fiber textile including different sensors which requires masonry with plaster  
  
  
the second objective was to test through extensive laboratory campaigns the performances of the multifunctional textiles systems for masonry seismic reinforcement and monitoring based on the selected technologies and by using the conceived tests methods.   
in this framework, multitexco defined a set of program tests in order to evaluate the performances of the new generation of multifunctional textiles for seismic reinforcement and monitoring. in particular, two test set-ups have been defined, the first one for the system conceived for indoor application, the second one for the system conceived for outdoor application. furthermore, the test set-ups included both the evaluation of the only reinforcing systems as well as the assessment of the sensorized systems.   
  
set-up for indoor system - test methods for assessing:  
1) performance of the textile component of the retrofitting system  
2) performance of the glue/ matrix component of the system:  
- modified bonding tests  
- modified shear tests (two different test concepts)  
- due to the lack of normative provided reference test procedures own test setups had to be created and to be iteratively modified to acquire data within a reasonable range of scatter  
2) performance of the applied system  
- single shear tests: evaluation of system performance in terms of maximum textile strain at debonding for different boundary conditions   
- bending specimens: evaluation of system performance for the applied system on masonry samples in a three-point bending test  
3) evaluation of durability performance:  
- examination of the durability of the textile component in alkaline environment  
4) evaluation of sensor integration concepts using fiber optical sensors:  
5) evaluation of sensor integration concepts using conductive fibers to form a self diagnostic composite  
  
set-up for outdoor system- test methods for assessing:  
1) performance of the textile component of multiaxial hybrid retrofitting system  
- evaluation for the textile not embedded in mortar  
- evaluation for the textile embedded in mortar:  
2) performance of the mortar component system  
3) performance of the applied system  
- evaluation of bonding behaviour  
- evaluation of shear strengthening behaviour   
- evaluation of reinforcing effect in terms of increasing strength and deformability for shear walls  
4) evaluation of durability performance:  
- examination of the durability of the textile component in alkaline environment  
5) evaluation of sensor integration concepts using a ready for use on construction site sensorised textile.  
  
furthermore, in order to assess the expected behaviour on the field of both systems (outdoor, indoor) specific test methods have been conceived.   
in this context, the most important physical properties to be monitored have been considered:  
- textile strain  
- displacement (via numerical integration of strain data)  
the selection of these parameters allows a direct linking between the sensor data obtained and normative determinable - or during the test campaign evaluated parameters.  
the monitoring concept envisages data acquisition within specific intervals before or after a seismic event has taken place. to assess both, the need for monitoring standardized data in a reproducible way and the chosen monitoring concept, an optimum test configuration have been set-up.  
catalogue of requirements for an optimum test configuration:  
â¢ inducing of specific failure modes at monitored locations  
â¢ well known boundary conditions in terms of load and displacements for monitored areas  
â¢ well known boundary conditions (load and displacement) being constant during the duration of a sensor data acquisition (~1 min.), that means that the loading procedure must be âfreezedâ at a certain point  
test configuration:  
â¢ isolation of representative and clearly defined parts of a masonry building  
â¢ âshaking table segmentsâ cyclic/quasi static loading procedure: test setup which enables induction of clearly defined loads (force and displacement) at every time point of the measurement.  
the characterization has been completed by both systems by using the above illustrated test methods.   
after the characterization of the developed multifunctional textiles, the final objective for masonry applications was to define their application guidelines: this has been achieved for both systems, mhm and gfp.   
  
geotechnical applications  
multitexco proposed two different approaches for using multifunctional geotextiles (mfg):  
- in the first one referred as "multi-functional geotextile (mfg) material solution", the same textile used for soil reinforcement is sensorized and therefore it is able to provide monitoring data.   
- in the second one referred as "multi-functional geotextile (mfg) system solution", the reinforcing and the monitoring functions are attributed to two different textiles, with different and complementary characteristics, to be utilized in coordinated way.  
the geogrid investigated in the framework of the project exhibits both reinforcing and monitoring capabilities thanks to the embedded optical fibers. devoted test methods have been developed during multitexco in order to fully characterize the geogrid and to define its specifications.  
in this framework, multitexco defined a set of program tests in order to evaluate the performance of the new generation of multifunctional geotextiles having both reinforcement and monitoring capabilities. the test methods proposed in the framework of multitexco aimed at understanding the functioning of multi-functional geotextiles. in particular after ...

# MULTITEXCO

Project Acronym: MULTITEXCO

programme & topic: FP7-SME SME-2013-2

Most frequent returning words in objectives:

* ('textiles', 38)
* ('structures', 34)
* ('project', 32)
* ('textile', 30)
* ('multifunctional', 29)
* ('monitoring', 29)
* ('masonry', 29)
* ('applications', 26)
* ('multitexco', 24)
* ('application', 24)
* ('tensile', 21)
* ('construction', 20)
* ('test', 20)
* ('system', 18)
* ('reinforcement', 17)
* ('order', 17)
* ('sensor', 16)
* ('performance', 15)
* ('methods', 14)
* ('sector', 13)
* ('relevant', 13)
* ('products', 13)
* ('systems', 13)
* ('evaluation', 13)

executive summary:  
the multitexco project goal was to scientifically and technologically characterize the latest achievements in multifunctional technical textiles, allowing the definition of guidelines and best practices for their optimal use in the construction industry and hence supporting the smes involved in the sector to fully exploit the potential of such materials.  
textile materials are widely used in construction, where the recent catastrophic events (e.g. the earthquakes that struck italy in 2012 and 2016) highlighted the need of efficient methods and technologies for both retrofitting and structural monitoring. in the last decade, considerable boost in the development of advanced textiles has been provided by a number of research and innovation projects, addressing in particular the construction sector.   
however, despite the benefits and potentials demonstrated by these projects, the market uptake of such solutions is still not as wide as expected, mainly due to some issues still partially unsolved: the non-availability of tests methods for multifunctional textiles to provide certifications, the lack of quantification models especially for reinforcing textiles, the lack in codes and standards and finally the need for a knowledge transfer to companies in the construction sector to foster the practical adoption of these materials. indeed, many building practitioners are still unfamiliar with the behavior and the characteristics of these technical textiles. shortage of information to the design and construction community about use and properties of these materials heavily limits their exploitation potential and consequently their practical adoption.   
in this framework, the aim of multitexco was to support the competitiveness of the european smes of the construction and technical textile sectors by addressing the above mentioned needs by means of the development of scientific knowledge, testing procedures, guidelines and pre-normative research, enabling future standards at eu level to support smes to fully exploit the new generation of multifunctional technical textiles in a more efficient, effective and profitable way. the following application fields have been targeted by the project: masonry seismic reinforcement, geotechnical applications and tensile structures.   
actually, examples of multifunctional textiles for the construction sector comprise textile based structures used for the rehabilitation of buildings, providing both strengthening and monitoring functions, geotextiles for the stabilization and monitoring of soil structures such as railway or roadway embankments and high performance technical textiles for tensile structures for covering large areas such as stadiums or exhibition areas to name a few.  
the ambitious multitexco goal was far away to be achieved by the capability of a single sme and required a collective r&d effort led by sme associations at european and national level. the project addressed the needs of the sme members of 5 associations throughout eu to access to the newly developed smart textiles in a more efficient, effective and profitable way. the project was coordinated by texclubtec, the italian association of technical textiles, and included in the consortium also the belgian association unitex, the association clutex (czech republic) as well as the roofing association catider (turkey) and vpi (germany). moreover, the project included three smes, selcom (italy), arimeks (turkey) and maco technology (italy) and four rtd performers entrusted to carry out the research activities in the frame of the project: dâappolonia (italy), karlsruhe institute of technology (germany), acciona (spain) and centexbel (belgium).   
key objectives of the multitexco partners were the development and characterization of :  
-multifunctional textiles for masonry application having both reinforcement and monitoring capabilities  
-sensor embedded geotextile structures  
-sensorized textile membranes for tensile structures  
project context and objectives:  
the overall objective of multitexco project was the scientific and technological characterization of the latest achievements in multifunctional technical textiles in order to pave the way to the market uptake of these solutions. actually, textile materials are widely used in construction in both ground and building structures. unreinforced masonry structures are highly vulnerable because, being originally designed mainly for gravity loads, they often cannot withstand the dynamic horizontal loads in case of strong earthquakes. soil structures, such as embankments, are subjected to landslides after heavy rainfalls or during earthquakes, as witnessed by the recent tragic events in italy. hence, the necessity of efficient methods and technologies for the retrofitting of existing buildings and earthworks and for the related monitoring to possibly prevent the structural damage is clearly evident. examples of advanced composites for the construction sector comprise textile-based structures used for buildings rehabilitation or seismic upgrading, geotextiles used for the stabilisation of soil structures, such as railway or roadway embankments, while high performance technical textiles are used for tensile structures covering large areas, such as stadiums or exhibition areas. in all such applications, the novel textile materials potentially offer a brand new functionality in addition to the main functions of the standard technical textiles, namely the possibility of monitoring the structural health of the reinforced structure. the health state of a building or earthwork can be assessed through the use of structural health monitoring (shm) techniques at different stages of the construction life, namely construction, inspection, operation, dismantling. moreover, measurements can be carried out after a severely damaging event (for instance an earthquake), in order to assess the state of the structure and its remaining service life. measurements over time can be used to track changes in structural performance, addressing repair actions when appropriate. despite the above-mentioned benefits, many building practitioners are still unfamiliar with the behaviour and the characteristics of these materials. shortage of information to the design and construction community about use and properties (mainly long-term behaviour) of these materials limits their exploitation potential and consequently their practical adoption. moreover, as these high innovative solutions are derived either from modification of existing materials or from newly developed high performance textile materials, in general new codes, specifications, guidelines and standard test methods are required for the purpose of their design, use, testing and certification.  
in this context, multitexco aimed at the definition of tests methods, guidelines and best practices though pre-normative research in order to enable the development of future standards able to favor the wide use of the new generation of multifunctional textiles for the construction sector. the specific target applications of multitexco were:  
â¢ masonry seismic reinforcement and monitoring  
â¢ geotechnical applications  
â¢ tensile structures  
in particular, the following main objectives were expected to be achieved by the project:  
1) the identification and characterization of relevant existing and newly developed products by means of extensive scientific characterization, laboratory work and field tests, leading to define design and application procedures. a complete characterization under laboratory as well as under working conditions in simulated harsh environments were expected in order to assess the specific performances of the different multifunctional textiles investigated.  
2) the delivery of a sound scientific basis for the new generation of multifunctional textiles in order to favor the standardization process at the eu level also by means of a close link with the standardization bodies.  
3) the delivery of a knowledge management platform to be provided to the sme-ags as proprietary tool transferring them the project results and including:  
- the knowledge repository, gathering the technical specifications and information about the new advanced technical textiles, detailing their functions, features, costs, application procedures etc;  
- the customization support tool, enabling the users to select the most suitable solutions and products for each specific targeted sector (masonry seismic reinforcement, geotextiles, tensile structures) according to intervention type, specific application scenario, conditions, location and cost target, providing all the information about application procedures and performances.  
- the e-learning modules, providing smes with a tool able to train the end users and the smes members of the multitexco associations on using the new technologies.   
the knowledge management platform allows accelerating the introduction in the market of the new products in each specific application sector by facilitating their dissemination, demonstration and by supporting the smes through training activities. in addition, the testing procedures, the case studies, and the platform itself will provide smes with a mechanism to develop and promote their own products. moreover, the definition of application guidelines and testing methods, addressed by the multitexco project as pre-normative research, will provide significant inputs for the development/improvement of standards and for the certification of the new advanced textile materials, including new sensors and structures.  
4) a complete lca and lcc analysis allowing verifying the impact of the new technologies on the environment, as well as providing a sustainability comparison of existing solutions with the new products and procedures. the lcc allows evaluating the impact of the new products from an economic point of view in a whole lifecycle perspective, taking also into account the actual cost for the maintenance and repairing of buildings and other target structures.  
all the above-mentioned objectives have been fully achieved by the project.   
  
project results:  
multitexco focused its activity on the following target applications:  
â¢ masonry seismic reinforcement and monitoring  
â¢ geotechnical applications  
â¢ tensile structures  
at the beginning of the project, a review of the state of the art technologies and procedures applied for technical textiles, as well as the relevant standards, has been delivered for each target application. moreover, a comprehensive market analysis for the related applications has been provided, together with an inventory of all the relevant rules, standards and policies at national and international level.   
one of the main areas of investigation in the frame of technical textiles for the construction sector, in the last decade, has been the one related to the retrofitting of existing masonry walls with smart textiles for the rehabilitation of buildings and providing both strengthening in case of earthquakes as well as monitoring functions (shm). an accurate literature analysis has been carried out in order to identify the relevant advancement in this area.   
the analysis was performed at three different levels:   
â¢ relevant r&d projects  
â¢ optical fibers   
â¢ products on the market  
between the relevant r&d projects identified, it is worth to mention:   
â¢ polytect project  
â¢ polymast initiative   
â¢ insysm project  
in particular, the fp6 large-scale collaborative project polytect for small and medium enterprises (smes) ended in the 2010 pushed the state of the art for technical textiles through the development of large area sensor-embedded multifunctional textiles (seismic wallpaper) employing fiber optic sensors for masonry applications. the composite seismic wallpaper has been conceived as a full-coverage or wide-area reinforcing solution for unreinforced masonry buildings and structures. concerning the preliminary analysis on optical fibers, the study has been mainly focused on:   
â¢ polymer optical fiber (pof)   
â¢ optical physical fbg sensors  
an overview was then carried out on each of the two fiber types. in particular, regarding pof sensing, the focus has been on the following aspects:  
â¢ type of pof used  
â¢ sensor type  
â¢ strain resolution  
â¢ dynamic range  
â¢ relative sensor cost  
â¢ relative equipment cost  
â¢ key features & remarks  
regarding fbgs, after the investigation about fbg principle and specifications, the measurement topology allowing sensors multiplexing on a fibre thanks to the use of different wavelengths was analyzed. special attention has been paid on the possibility of directly embroider the fbg sensor optical fiber directly on the textile. in particular, the focus has been on the possible impact on the structural integrity of both the optical sensor fiber and the glass/carbon textile during the whole integration process of the fbg through embroidery.   
then it has been decided do not limit exclusively the analysis to pof and fbg sensors and in order to select the best solutions to be implemented in multitexco, the investigation about optical fibers has been therefore fully completed by classify them according to the following:  
- core material type;  
- spatial disposition of measures;  
- sensing technique.  
according to each of the above criteria, the main typologies can be pointed out as in the following (focus has been mainly given to commercially available solutions allowing long measuring range).  
core material type:   
- polymeric optic fiber (pof)   
- glass (silica)optic fiber (gof)  
  
spatial distribution of measures:  
- discrete (short-gage and long-gage)  
- quasi-distributed  
- distributed  
  
sensing technique:  
- grating-based (fbg, lpg)  
- raman scattering  
- brillouin scattering  
- rayleigh scattering   
- fabry-perot (intrinsic or extrinsic)  
- sofo  
- other techniques  
  
moreover, further distinction can be made:  
- standard telecommunication cable (though properly buffered) or a special cable can be used for sensing  
- single-mode or multi-mode fibers can be used: multi-mode fibers are usually advisable for intensity-based technique, requiring higher signal intensity, though they imply higher attenuation (and then shorter measurable length);  
- intrinsic or extrinsic sensor: in an intrinsic sensor, modulation of the optical signal is a direct result of the physical change in the optical fibre in response to some measurands (e.g. signal change due to the micro- or macro-bending of the fibre); in an extrinsic optical fibre, the signal modulation takes place outside the optical fibre (e.g., signal change due to the changing gap distance between two cleaved fibre surfaces).  
a specific sensor is characterized by a defined set of features, each one describing its characteristics with respect to a certain classification criteria. it is worth pointing out that not all the combinations of the features are possible (ex. point-wise sensors cannot be based on brillouin sensing technique).  
on the basis of this analysis, the optical fibers to be used in multitexco have been selected.   
concerning the technical textile products on the markets, the analysis evidenced that, currently, no products for masonry applications able to both reinforcing and monitoring buildings are present on the market. the commercial systems available on the market can provide only strengthening and retrofitting functionalities (e.g. : rãfix and mapei products).   
  
concerning multifunctional textiles for earthwork, geotextiles have been successfully used in a wide variety of applications for over twenty years in the geotechnical and construction sector. the principal applications include unpaved and paved roadway as well as railway systems, erosion and sediment control systems, subsurface drainage systems, waste containment systems, reinforced soil structures, etc. geotextile reinforced soil structures include steep slopes and embankments over soft soils.  
the state of the art has been analyzed with respect to:  
- relevant r&d projects  
- existing products on the market  
concerning remarkable research projects, the most relevant r&d project with respect to this topic is again polytect, already described with reference to masonry structures, which focused also on earthworks. the solutions developed in the framework of polytect have been based on optical fibers. in polytect project, pof have been investigated as a distributed strain sensor by analyzing the backscatter increase at the strained section using the optical time domain reflectometry (otdr) technique. thanks to their ruggedness, it is possible to directly weave the pof into the textile during the fabrication process and obtain a good and direct force and strain transfer from the textile to the light guiding core of the pof. the textiles not only fulfill the function as a sensor support, they also facilitate the direct transfer of deformations of the structure into measurable strain in the fiber. the strong and the weak point of polytect solutions have been accurately analyzed.   
concerning the products on the market, the following have been investigated:   
â¢ gedise by gloetzl (based on distributed pof sensors)  
â¢ tencate geodetectâ® (based on fbg)  
â¢ must smartgeotex from smartec (based on fbg)   
then an accurate analysis has been carried out in order to identify the most appropriate optical fibers to be used as done also for masonry applications. for the geotechnical application envisaged in multitexco, the most relevant specifications that have been considered were the following:  
- spatial resolution  
- spatial accuracy  
- strain resolution  
- max strain   
- max measurable length  
- max measurement frequency  
  
according to the study, the optical fibers to be used in multitexco have been selected.   
  
as far as the multifunctional textiles for tensile structures are concerned, different solutions for the coating of textile membranes to be used in tensile structures are available at the state of the art and they have been investigated:   
â¢ ptfe â teflon coated fiberglas  
â¢ kynarâ¢ coated membrane/dupont tedlarâ¢ coated membrane  
â¢ acrylic/pet pvc coated membrane  
â¢ high density polyethylene  
â¢ efte foil  
â¢ etc.  
then the focused have been moved on sensing technologies to be embedded in the membranes.  
in the first phase of the project, special attention has been paid in the definition of the requirements of the systems to be developed.   
actually, the multitexco sme associations had a relevant role together with the end users and the rtd performers in order to establish the technological needs and the technical requirements of the new multifunctional technical textiles for each application target of the project. the work has been completed during the first 9 months of the project.  
in this framework, the key features/parameters (as well as the possible sensing technologies) to be investigated in order to characterize the multifunctional textiles enabling their effective use in the construction sector have been defined. in particular, for each target sector of the project (masonry seismic reinforcement, geotextiles and tensile structures) two specific applications have been defined. the parameters to be measured or monitored by using the new generation of multifunctional textiles have been fixed and a selection of possible sensors/sensing technologies to be investigated during the project for the integration in multifunctional textiles has been identified. furthermore, the expected performances to be measured by adequate test methods in the frame of the rtd work packages have been defined.  
as far as multifunctional textiles for masonry seismic reinforcement applications are concerned, since the beginning of the project, one of the scopes has been the definition of the sensing capabilities of the seismic wallpaper for a full coverage of masonry buildings for achieving along the project development the fully characterization of the system. concerning the sensing capabilities, the first objective was the assessment of the building structural status before and after an event (earthquake). two specific applications taking into account the needs of the end users have been defined for the concept of seismic wallpaper aiming at a post-assessment of earthquake event:  
â¢ system to be applied on the internal walls surface of the building for the assessment of structural integrity before and after a seismic event as well as for the seismic certification  
â¢ system to be applied on the external walls surface of the building for the assessment of structural integrity before and after a seismic event as well as for seismic certification  
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â¢ system for outdoor application (mhm): mortar embedded multiaxial, hybrid glass fiber textile including optical fibers which requires masonry without plaster  
â¢ system for indoor application (gfp): bi-axial glass fiber textile including different sensors which requires masonry with plaster  
  
  
the second objective was to test through extensive laboratory campaigns the performances of the multifunctional textiles systems for masonry seismic reinforcement and monitoring based on the selected technologies and by using the conceived tests methods.   
in this framework, multitexco defined a set of program tests in order to evaluate the performances of the new generation of multifunctional textiles for seismic reinforcement and monitoring. in particular, two test set-ups have been defined, the first one for the system conceived for indoor application, the second one for the system conceived for outdoor application. furthermore, the test set-ups included both the evaluation of the only reinforcing systems as well as the assessment of the sensorized systems.   
  
set-up for indoor system - test methods for assessing:  
1) performance of the textile component of the retrofitting system  
2) performance of the glue/ matrix component of the system:  
- modified bonding tests  
- modified shear tests (two different test concepts)  
- due to the lack of normative provided reference test procedures own test setups had to be created and to be iteratively modified to acquire data within a reasonable range of scatter  
2) performance of the applied system  
- single shear tests: evaluation of system performance in terms of maximum textile strain at debonding for different boundary conditions   
- bending specimens: evaluation of system performance for the applied system on masonry samples in a three-point bending test  
3) evaluation of durability performance:  
- examination of the durability of the textile component in alkaline environment  
4) evaluation of sensor integration concepts using fiber optical sensors:  
5) evaluation of sensor integration concepts using conductive fibers to form a self diagnostic composite  
  
set-up for outdoor system- test methods for assessing:  
1) performance of the textile component of multiaxial hybrid retrofitting system  
- evaluation for the textile not embedded in mortar  
- evaluation for the textile embedded in mortar:  
2) performance of the mortar component system  
3) performance of the applied system  
- evaluation of bonding behaviour  
- evaluation of shear strengthening behaviour   
- evaluation of reinforcing effect in terms of increasing strength and deformability for shear walls  
4) evaluation of durability performance:  
- examination of the durability of the textile component in alkaline environment  
5) evaluation of sensor integration concepts using a ready for use on construction site sensorised textile.  
  
furthermore, in order to assess the expected behaviour on the field of both systems (outdoor, indoor) specific test methods have been conceived.   
in this context, the most important physical properties to be monitored have been considered:  
- textile strain  
- displacement (via numerical integration of strain data)  
the selection of these parameters allows a direct linking between the sensor data obtained and normative determinable - or during the test campaign evaluated parameters.  
the monitoring concept envisages data acquisition within specific intervals before or after a seismic event has taken place. to assess both, the need for monitoring standardized data in a reproducible way and the chosen monitoring concept, an optimum test configuration have been set-up.  
catalogue of requirements for an optimum test configuration:  
â¢ inducing of specific failure modes at monitored locations  
â¢ well known boundary conditions in terms of load and displacements for monitored areas  
â¢ well known boundary conditions (load and displacement) being constant during the duration of a sensor data acquisition (~1 min.), that means that the loading procedure must be âfreezedâ at a certain point  
test configuration:  
â¢ isolation of representative and clearly defined parts of a masonry building  
â¢ âshaking table segmentsâ cyclic/quasi static loading procedure: test setup which enables induction of clearly defined loads (force and displacement) at every time point of the measurement.  
the characterization has been completed by both systems by using the above illustrated test methods.   
after the characterization of the developed multifunctional textiles, the final objective for masonry applications was to define their application guidelines: this has been achieved for both systems, mhm and gfp.   
  
geotechnical applications  
multitexco proposed two different approaches for using multifunctional geotextiles (mfg):  
- in the first one referred as "multi-functional geotextile (mfg) material solution", the same textile used for soil reinforcement is sensorized and therefore it is able to provide monitoring data.   
- in the second one referred as "multi-functional geotextile (mfg) system solution", the reinforcing and the monitoring functions are attributed to two different textiles, with different and complementary characteristics, to be utilized in coordinated way.  
the geogrid investigated in the framework of the project exhibits both reinforcing and monitoring capabilities thanks to the embedded optical fibers. devoted test methods have been developed during multitexco in order to fully characterize the geogrid and to define its specifications.  
in this framework, multitexco defined a set of program tests in order to evaluate the performance of the new generation of multifunctional geotextiles having both reinforcement and monitoring capabilities. the test methods proposed in the framework of multitexco aimed at understanding the functioning of multi-functional geotextiles. in particular after ...

# TEXTHA

Project Acronym: TEXTHA

programme & topic: FP7-PEOPLE FP7-PEOPLE-2012-IEF

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* ('hittite', 29)
* ('fellow', 11)
* ('words', 10)
* ('textiles', 10)
* ('research', 9)
* ('analysis', 6)
* ('creation', 6)
* ('chicago', 6)
* ('terms', 6)
* ('prof.', 5)
* ('attestations', 5)
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* ('training', 5)
* ('sources', 4)
* ('corpus', 4)
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* ('nosch', 4)
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1. the creation of a complete onomasiological index of the hittite textiles on the basis of the critical analysis of the supposed meaning of the textile-related words in hittite contexts. the onomasiological index consists of a list of words in hittite language according to materials (wool, linen, etc.); untailored fabrics (yarns, strips, rolls, etc.); tools (spindles, distaffs, looms, loom-weights, etc.); clothes for different parts of body (hats, headbands, gloves, shoes, underclothes, shirts, tunics, mantles, etc.); garments according to a socio-stratigraphic selection (used by men, women, slaves, court officers, soldiers, kings and queens, priests, etc.); textiles in literary contexts with symbolic value (textile metaphors or expressions);   
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http://ctr.hum.ku.dk/economy/textha/

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# FLHEA

Project Acronym: FLHEA

programme & topic: FP7-KBBE KBBE.2013.1.4-07

Most frequent returning words in objectives:

* ('cellulose', 35)
* ('packaging', 31)
* ('market', 30)
* ('properties', 28)
* ('development', 23)
* ('project', 23)
* ('production', 21)
* ('food', 17)
* ('flax', 16)
* ('materials', 15)
* ('hemp', 15)
* ('flhea', 15)
* ('material', 14)
* ('increase', 13)
* ('fibres', 12)
* ('applications', 12)
* ('poultry', 12)
* ('trays', 11)
* ('industry', 10)
* ('composites', 10)
* ('content', 10)
* ('scale', 10)
* ('surface', 9)
* ('matrices', 9)

executive summary:  
packaging application is the greatest sector for the plastics industry in europe. one of the main challenges in this industry is the control of wastes after use. in order to reduce the environmental load generated from the disposal of used plastic materials, a growing interest has been focused on biodegradable polymers based materials. however, the use of biodegradable films for food packaging has been strongly limited because of the poor barrier properties and weak mechanical properties shown by natural polymers. a possible strategy to increase its properties is the development of fibre-based biocomposites. in this sense, natural fibres represent an interesting profitable substrate, being most of them plant fibres. although the demand for natural fibers is growing worldwide and its price is increasing, annual plants such as jute, sisal, kenaf, flax or hemp require further development to provide novel products with improved properties.  
the development of flhea project has provided a novel range of surface modified reinforcements. the project has been focused on the upscaling and modification of micro/nanoreinforcements based in hemp and flax, and its subsequent processing to obtain composites with improved properties. extruded sheets have been performed and subsequently thermoforming of food packaging trays. flax and hemp fibres were selected because their high cellulose contents together with a low lignin content to provide a faster processing route for the isolation for cellulose micro/nanofibres (cmf/cnf) and the extraction of crystalline cellulose regions, as cellulose nanowhiskers (cnw). different processing routes have been evaluated in order to provide a completely renewable and biodegradable compound based on surface modified nanofibres for packaging applications.  
works carried out in flhea project have consisted in developing methods for easy handling and manipulation of cellulose fibres. from these fibres, nanocrystalline cellulose fractions were isolated and chemically modified in order to increase the interaction with the hydrophobic polymer matrices and also to prevent the agglomeration during compounding. once compounding process parameters were optimized to assure the desired distribution of the reinforcing phase in the polymeric matrix, co-extruded sheets were performed at pilot scale. industrial up-scaling have been also carried out for thermoforming final trays.  
  
project context and objectives:  
context  
flax and hemp have been used since centuries ago, and have become agricultural commodities cultivated for its application on a wide range of products such as long fibres for fabric, short fibres for paper or felt; seeds and oils for livestock feed, or use as compost, among others. these crops represent an important area on european agricultural sector. according to celc, 81.300 hectares of flax fibre were cultivated in 2014 on europe amounting to 80% of the worldâs production, accounting for 12.000 direct jobs. china is among the largest producing and exporting countries of hemp textiles and related products, while european union (eu) has an active hemp market, with production in most member nations.   
however, there is a need to develop novel products to offer a differentiated and competitive product as a result of globalised economies. flax and hemp have been used on the development of bio-composites, leading to innovative new applications and opportunities for these industries. the advantages of flax and hemp reinforcements are based on the development of lower weight and enhanced properties composite materials. during the last years the development of nanocomposites, has led to a novel field of material development. these materials have reinforcements with at least one dimension is below 100 nm, leading to enhanced or novel properties compared to conventional composites reinforcements.   
in europe, packaging applications are the largest application sector for the plastics industry and represent 39.6% of the total plastics demand, which was around 46.3 mton on 2013, according to latest plastics europe analysis. from post-consumer waste, 62% was recovered through recycling and energy recovery processes while 38% still went to landfill. bioplastics can offer a potential alternative to conventional plastics, based on oil. according to european bioplastics, about 75 percent of bioplastics will be produced in asia by 2018. europe will play its role mainly on research and development, and production capacity will be around 8% worldwide.   
however, bioplastic properties or performance are usually below its oil counterparts, and therefore, nanocomposites may offer a potentially applicable route to improve properties.   
flhea project scope has been based on the implementation of a technical approach to the upscaling of composites, and specifically, to cellulose-based nanocomposites. this research is based on a previous project development (traysrenew), and has been focused on the increase of cellulose isolation and nanowhiskers yield, its modification to enhance compatibility to polymeric matrices, and the production and evaluation of parts at industrial scale.  
  
objective  
the main objective of flhea project is the development of industrial scaled-up processes to obtain modified cellulose nanowhiskers, for the development of biocomposites with improved properties to perform thermoformed trays for food packaging applications.  
this scope will assure the development of biodegradable fibre-based composites ready for the use and commercialization on packaging industry. flhea industrial process will be high-throughput, environmental, and energetic and cost efficient.  
  
project results:  
the performance of flhea project has achieved to develop a completely renewable and biodegradable compound based in surface modified nanofibres derived from bast fibres. a homogeneous composite material based on fibres has been performed and it is suitable for packaging applications.  
some specific objectives have been implied and reached in flhea project development:  
â¢ improve extraction steps of cellulose fraction in bast fibres:  
the most adequate raw material has been selected for cellulose extraction and purification. it has been obtained cellulose with low lignin content.  
â¢ nanoreinforcements isolation. mechanisms to be considered:  
the upscaling of the ncc manufacturing by evaluating different purification and isolation techniques have been optimized.  
â¢ enhancement of matrix-fibre interface:  
successfully reached by introducing chemical modifiers in nanocellulose surface. besides, optimizations of drying techniques and plasticizers addition in composite formulations have been performed.  
â¢ to develop a cost effective technology to obtain cellulose from hemp and flax natural fibres:  
the most effective method for cellulose pulp drying and storage has been developed.  
â¢ design of a optimised production scheme for nanoreinforcements:  
an up-scaling process has been optimized reaching maximum yield, minimum water and energy consumption.  
â¢ adjustment of surface modification reactions:  
different chemical modifiers have been used for optimizing the interface fibre-matrix.  
â¢ to develop a sustainable composite material with optimal mechanical, thermal and barrier properties for food packaging applications:  
several pla based composites have been successfully processed and evaluated for being suitable in food packaging applications.  
  
these objectives have been successfully achieved through the application of different approaches. it has been considered as multiple developments, in which the final product is affected also by the surface modification of cellulose nanofibres and their introduction with different biodegradable polymer matrices.   
work developed within the project has involved a four step approach. first it was to extract and purify cellulose and after nanocrystals were isolated. the second part aimed the study about chemical modifiers for selecting the most appropriate in order to increase the interaction with the hydrophobic polymer matrices. on a third stage, compounding process for introducing modified nanocellulose within pla and starch-based polymers was optimized at lab and pilot scales. finally, main efforts were devoted to carry out the implementation at industrial scale for obtaining coextruded sheets and thermoformed trays suitable for food packaging applications.  
  
below it is presented the main technological results and foregrounds achieved in each work package of the development of the project:   
  
wp1- âcelulose purification and isolationâ  
this work package (wp1) was focused on the selection of the most adequate raw material, cellulose extraction and purification. it was reached and the proposed target was also fulfilled, by obtaining cellulose with the minimum lignin content than possible.  
during the development of this work package, large amount of raw materials supplied by arctic fiber company ltd. were processed to produce bleached cellulose pulp for wp2. for this purpose the optimized sequence reported in deliverable d1.2 was used. the best results in term of cellulose content were obtained with enzymatic-retted flax that presented the major descent in lignin from the raw material (7.6 to 3.15%). enzymatic retted flax fibres presented diameter value of 19.83 î¼m and length with values around 300 î¼m.  
in addition, a very effective method for cellulose pulp drying and storage has been developed. in one of the submitted deliverables a brief overview of different drying techniques has been provided, with a special focus on those techniques applied at industrial level and on conventional pulp mills. among the screened techniques, flash drying provides the tool for a high output product that can be applied in the project development.  
the major findings were as follows:   
â¢ all raw materials supplied by arctic fiber company ltd. presented high content of cellulose and low content of lignin.  
â¢ the bleached pulps presented less proportion of phenolic compound than commercial cellulose and produced mainly for decomposition of cellulose.  
â¢ different available drying technologies were identified.  
â¢ the advantage and inconvenient of these technologies for cellulose pulp drying were identified.  
â¢ impact of the drying on the properties of cellulose was identified.  
â¢ flash drying was selected as the most adapted technology for the project.  
  
wp2- âmicro/nanofibre up-scalingâ  
this work package was focused on isolation and production of nano crystalline cellulose (ncc or cnc) from purified hemp and flax fibers. the main aim was to optimize the upscaling of the ncc manufacturing by evaluating different purification and isolation techniques.  
during the first period of the project, the work carried out was concentrated in improving the ncc production yield obtained in traysrenew project. then, during the second period of wp2, the work was focused on the final step in the ncc production-washing of the suspension, in order to improve the total yield.  
with this project development, production conditions of ncc from bleached flax and hemp at pilot scale were optimized. finally, higher production yield was obtained by using melodeaâs protocol in which some optimization was performed to flhea development project. also an optimization of lab pilot scale production, in terms on reducing energy and water consumption, has been performed.  
some analyses were performed in both gel and dry form of ncc, produced from flax and hemp such as: transmission electron microscopy (tem), scanning electron microscopy (sem), atomic force microscopy (afm), thermogravimetric analysis (tga), fourier transformed infrared spectroscopy (ftir), rheology measurements. these analyses served as tools to improve the ncc production in order to obtain high solids content solution or powdered material through drying for the next stage in the process in which the nano crystals are modified, pumped and extruded. to optimize the ncc form needed for applying surface modification, different forms of ncc were delivered for testing by organoclick ab.  
since flax fibers have a significant higher î±-cellulose content compare to hemp, they were a preferable candidate to produce ncc in pilot scale and gain by that a higher production capacity and therefore more cost effective compare to hemp.  
the main target of this work package was established, and ncc production yield compare to traysrenew (less than 30%) was improved significantly. the average yield obtained by melodea up scaled production is 65.4â±3.7%.  
more than 54 litres of ncc suspension were prepared and delivered for the following step in the process, surface modification implementation.  
as well as isolated nanocrystals were prepared for subsequent chemical modification, these samples were evaluated by different drying methods, and the most applicable ones were based on spray drying. spray drying is a widely used industrial process for particle formation and drying. this technique is suited for a continuous production of dry solids in powder or agglomerated particles form from a liquid feedstock, providing precise quality standards such as particle size distribution, residual moisture content, bulk density and particle morphology. the drying proceeds until the desired moisture content is reached in the sprayed particles and the product is then separated from the air. different parameters were optimized and average yield obtained increased from 62 to 86%.   
  
wp3- âcellulose micro/nanofibres modificationâ  
the three different surface modifications of nanocellulose have been the introduction of a primary alkylamine (aptes), biopolymer based complex (pec) and vinyl functional groups. these types of modifications have successfully conducted by finding fda approved chemicals, reactive enough and with an acceptable economy to modify acidic non-sonicated flax nanocellulose.  
after optimization of the reaction conditions the time was spent on scaling up the reactions from 10 gram scale to 100 gram scale and subsequently to 200 gram scale dry modified nanocellulose.  
the modified nanocellulose films have been evaluated using contact angle measurements (40-90â°) and ftir analysis. additionally, suitable scaled up conditions have been identified and successfully synthesized to obtain â½1.5 kg dry modified nanocellulose. the products were delivered for the evaluation of drying procedures and also the compatibility with the polymeric matrix.  
an adjustment on cnw spray drying process has been evaluated to reduce remaining moisture in dried particles and also to increase production yield. once spray drying parameters were optimized, samples of modified cnw suspensions supplied by organoclick were spray dried and subsequently characterized.  
an alternative route of spray drying technique has been proposed and developed in this project to provide a suitable route to improve handling. the use of carrier systems has been evaluated to provide a valuable alternative to decrease the energetic requirements and potential aggregation of fibers. such carriers should be compatible with selected polymeric matrices to enhance the composite properties  
  
wp4- âfibre composite processingâ  
after evaluating different strategies, finally two processing routes has been defined to introduce cellulose nanowhiskers in pla and starch matrices. one of them consists on spray-drying process to obtain cnw in powder shape. the other alternative is the use of a plasticizer as a carrier to introduce cnw in polymer matrix. once pla and starch based composites were processed, mechanical, thermal and barrier properties have been evaluated, and then the best formulation to develop required composites was selected.   
regarding pla matrices, composite manufacturing has been achieved through twin screw processing, based on the dispersion of modified cellulose nanowhiskers on a plasticizer that will act as a carrier besides its effect on polymer properties.   
respecting bio based starch-pla polymers, some matrices were evaluated and then different cellulose dispersions were added through twin screw processing.  
  
wp5- âfinal packaging validationâ  
processing parameters have been adjusted to provide improved dispersion of cellulose nanowhiskers on the polymeric matrices, leading to optimized composites. coextruded pla sheets have been successful developed and subsequently thermoformed at pilot and industrial scale. it has been demonstrated the viability of thermoforming the new materials by processing trays with two different depth.  
in this work package an extend analysis has been carried out in up-scaled materials and also in final developed packaging. transparency, thermal and mechanical properties have been studied, and also a food contact evaluation has been done.  
the main conclusions obtained from these analyses are summarized below:  
â¢ an increase in crystallinity degree of pla containing modified nanocellulose is observed due to its nucleating effect.  
â¢ developed trays have been subjected to compression test and an increase on the range of 100% in stiffness was determined in higher depth trays when mcnw was added. in case of low depth trays, the effect on mechanical properties was not as high when nanofibres are included in composites; nevertheless it is shown an increase around 60%.  
â¢ the introduction of modified cnw in pla matrix containing plasticizer produces an increase around 30% in oxygen barrier properties.   
â¢ the materials employed in the flhea project fulfil the requirements of the plastic regulation (ue) 10/2011 concerning composition.  
  
potential impact:  
â¢ potential impact, exploitation  
at present, the looming effects of climate change have resulted in a renewed interest in materials derived from natural resources, like natural fibers. although the demand for natural fibers is growing worldwide and its price is increasing, annual plants such as jute, sisal, flax or hemp require further development to provide novel products with improved properties.  
packaging industry has a huge interest in reducing packaging materials and associated wastes, biodegradable materials have been evaluated for this application. there is no larger market segment in the plastics industry than the packaging segment. more than a third of all plastics are transformed into packaging, approximately 100 million tones worldwide. in industrialized countries such as the united states or the european union, 50 percent of all goods are packaged in plastics.  
however, the use of biodegradable materials for food packaging has been strongly limited because of the poor barrier properties and weak mechanical properties shown by natural polymers.  
the packaging industry needs advanced technical material properties and functionalities in order to achieve benefits such as increasing product attractiveness due mainly to its biodegradability, development of additional and new market applications, more competitive solutions than other competitors in the market and potential cost reduction.  
  
â¢ our innovative solution  
the use of nanocellulose materials reinforced by natural fibers in packaging is the major technological advancement in the improvement of properties in current packaging materials for market applications. therefore, flhea project is an opportunity to compete in the pla packaging market addressing main challenges of the packaging industry, first improving properties and second saving costs.  
flhea project proposes the development of industrial scaled-up processes to obtain modified cellulose nanofibres for the development of biocomposites with improved properties. this technology, demonstrated in the research project-traysrenew, will enable to commercialize the first sustainable food package with suitable mechanical and barrier properties that will open new market applications and represent a solution for the packaging industry.  
the potential impact on technical innovation and business competitive advantages are listed as shown:  
â¢ the use of renewable and biodegradable material.  
â¢ sustainable composite material with optimal properties: thermal, mechanical and barrier properties.  
â¢ product differentiation: composite material from natural fibers, compared to neat material.   
â¢ cost-effective technology.  
â¢ better packaging solution that avoids food waste. this point could be a condition in future commercial contracts.  
â¢ new market opportunities by having a new and differentiate product in the portfolio.  
â¢ the new package improves consumer perception (increase the sales).  
â¢ to improve sustainability image (brand recognition) due to the reduction of food waste.  
  
â¢ the attractiveness of the target market  
a market analysis has been performed considering three types of markets: provider (cellulose nanofibers), competitive (pla market) and end-use (poultry meat) market.   
â¢ provider market: cellulose nanofibers  
global revenues for nanofiber-enabled products were an estimated us$382.1 million in 2011, growing to around $852.3 million by 2017. main markets for polymer nanofibers are in air and water filtration, composites and textiles. global market potential of cellulose nanomaterials is expected to reach 35 million metric tons. the applications having the most important increase in volume of cellulose nanomaterials are paper and packaging.  
â¢ competitive market: pla market  
according to grand view research, inc., global pla market is expected to reach 1,205 ktons and $4,312 million by 2020, growing at a rate of 18.8%. pla demand for packaging products accounted for 59.6% of the overall pla market in 2013 and is expected to remain the relevant application segment over the years. among the application segment, food and beverage packaging held the largest market share.  
â¢ end-use market: poultry meat industry  
the poultry meat is one of the fastest growing meat sectors in terms of production and consumption. in 2013, the global poultry meat production reached 108 million tonnes and it is estimated to be worth over 128 million tonnes in 2022, growing at a rate of 2% each year from 2013. the north american region contributed to the global poultry meat production with 18.9 million tonnes in 2013, growing at a rate of 1.7% each year and the european meat production is expected to reach 13 million tonnes at a rate of 0.8% per year. other countries contributing to the growth of global poultry meat production are brazil, and china.  
this favorable market as well as the innovation factor provides a very positive scenario for the flhea project.  
  
economic impact of the businessthe european market considered for this business is the fresh packaged poultry market. according to organisation for economic cooperation and development (oecd) and food and agriculture organisation of the united nations (fao) projections, the potential market size is 6,100 million of trays for the first year in the european poultry meat packaging market. taking a conservative market share, the targeted packaging with reinforcements for poultry tray market will reach over 300 million.  
furthermore and according to the smithers pira report, around one-third of the fresh food consumed is packaged. nevertheless, there has been an increase in the proportion of packaged fresh food, largely as a result of consumer demand for convenience and the growing influence of major food retailers. different countries have very different packaged shares. the highest packaged shares tend to be in northern europe, particularly germany and the uk, and the lowest shares are in southern, central and eastern europe.  
this business will allow gaining a strong position in a growing european market and will provide a high economic impact to the partners involved. companies see a great opportunity to increase their economic benefits with the new solution. to highlight this impact, the total expected sales are expected to grow sharply, the profit generated will reach â¬5m in 2021, with a net present value (npv) of â¬8.4m. this is a high profitability business, estimated with an internal rate return (irr) of 74%.   
â¢ in order to reach these ambitious economic objectives, a global commercial and marketing plan has been designed with the necessary activities to make possible the business. in this sense, this plan has been designed in two phases, the first one will introduce the compound developed from flhea into the market and the second one will sell the trays made of the compound from flhea for the poultry sector. specifically, there have been defined three key activities to reach this profitable and sustainable business: direct sales by means of an own sales force who will be responsible for introducing the solution into the european market. the introduction of the new solution will be made in a gradual way. once the business has been introduced in europe, distributors will promote it in the usa. commercial agreements will be reached with top large companies in the field of interest. the selection will be based on their ability to effectively distribute the product.  
â¢ the key strategic partners: to effectively exploit this business model are lead companies of the business value chain (poultry producers, retailers, compounders). there have been already contacted with these potential partners taking advantage of our existing contacts and distributors. these first companies have been expressed their interest and will be the first companies to test the solution and create demand for the poultry trays made of the compound from flhea.  
professional association and trade fairs: sales activities will also be supported by dissemination actions such as main trade fairs and/or sectorial conferences in food packaging as exhibitor and/or visitant. besides, it will include specific website, leaflets, brochures, technical dossiers, samples to present the product, and specific commercial material support: training material for sales people and in-situ demo trials for companies. some of the main trade fairs and associations to promote the new solution are interpack, hispack & bta, ife, emballage and packnet  
  
list of websites:  
http://www.flhea.eu/

# ECOMETEX

Project Acronym: ECOMETEX

programme & topic: FP7-NMP NMP.2011.3.1-1

Most frequent returning words in objectives:

* ('product', 58)
* ('textile', 45)
* ('methodology', 40)
* ('products', 37)
* ('ecodesign', 33)
* ('floor', 32)
* ('process', 31)
* ('carpet', 31)
* ('project', 25)
* ('step', 25)
* ('coverings', 23)
* ('separation', 23)
* ('backing', 22)
* ('layer', 21)
* ('improvement', 19)
* ('reference', 18)
* ('material', 17)
* ('results', 16)
* ('analysis', 15)
* ('concept', 15)
* ('requirements', 15)
* ('carpets', 14)
* ('sector', 13)
* ('data', 13)

executive summary:  
1. executive summary  
the overall aim of ecometex was to develop a tailored ecodesign methodology for optimising the design of textile coverings with regard to eco-efficiency and cost-effectiveness.  
this comprises an analysis of the entire life cycle, identification significant environmental and economic impacts and hence potential for improvements, guaranteeing high product quality, as well as high product safety.  
life cycle assessment (lca) allows to identify the crucial weak points in the life cycle and to assess improvement strategies to achieve an environmentally sensitive product design. lca informs designers and developers concerning the implications of their choices on the environmental impacts and is therefore a decision-making tool.  
the innovative methodology faces the challenge to solve the paradox of textiles coverings:   
â¢ on the one hand the bonding of the multi layers has to be solid and high-quality raw materials are used in different combinations to ensure long lasting products.  
â¢ on the other hand the multi layers have to be easy to dismantle for recycling, but dismantling procedures to facilitate material recycling are not yet part of the product design processes. concepts focussing on technologies to recycle 'state of the art' textile coverings failed due to complex mechanical or chemical separation procedures and consequently due to their high cost- and low eco-effectiveness.  
re-design comprises not only optimisation of currently used material sets or manufacturing and distribution processes but also product and process innovations: it covers the development of innovative material adaptations as well as new approaches within the manufacturing process, recovery and reuse stage itself.  
the focus of the ecometex project is the design of a closed loop system of resources and raw materials enabling and facilitating full material recycling (see figure 1).  
the feasibility of the re-design concepts will be proven by producing prototypes of eco-designed textile floor coverings. the work will be completed by describing the methodology in a code of practice which will be implemented in a customised, practical and intuitive software tool. the environmental communication of the received results is based on lca results in the en 15804 format. these environmental product declarations (epds) are already widely used in the eu construction sector and provide data for architects and planers in a standardized format. the transferability of the ecodesign methodology for textile floor coverings to other sectors will be analysed using the example of luggage coverings for automotive applications representing the transport sector.   
to achieve these goals three basic strategies where selected:  
â¢ momomaterial approach  
â¢ separation layer approach  
â¢ material reduction  
the following report gives an overview on the basic findings within the project ecometex.  
  
project context and objectives:  
2. summary description of project context and objectives  
basically the project was divided into three parts:  
â¢ the first part was the development and implementation of an ecodesign methodology.  
â¢ the second part was the transfer of the developed methodology to the textile sector and the realisation and evaluation of an eco-designed floor covering.  
â¢ the third and last part was the transfer of the developed ecodesign method into another industry sector.  
  
2.1. development, implementation and evaluation of ecodesign methodology for textile floor coverings  
work package 2 âdevelopment, implementation and evaluation of ecodesign methodology for textile floor coveringsâ aimed at developing and implementing a systematic approach, the ecodesign methodology, for textile floor covering products. the applied methodology should have a strong whole life cycle approach, but also consider the different stakeholders (especially participating enterprises) together with their production processes and involved technologies. on the other hand the methodology had to be flexible enough to be applied to different textile products and industry sectors.  
the chosen system is therefore divided into 8 steps as shown in figure 2.  
the organization of different research teams has been identified as an important factor especially in the early phase of the work. the objective was to establish the basis for collaboration and exchange of information and data on the products to be assessed. the selection and description of the products and the understanding of the motivations and expectations of all project partners in the consortium were important joint objectives of ecometex. in addition, the structure of the ecodesign methodology in eight steps had to be customized with the active participation and inputs of the partners involved in the project. the objective was to develop the general framework and the specific data collection instruments for each step, namely, for the product description, environmental assessment, stakeholder analysis, process analysis, benchmarking analysis, product and process improvement, new textile concept and environmental communication. the developed templates should contain all the important product, process data, and environmental information for the assessment, and as such, the templates should become the instruments for the real data collection with the companies in the project. therefore, a balanced approach was needed, for the depth and level of details, and the effort required for data collection.  
the expected results from the assessment should include for example, the technical description of the products, their environmental assessments, the process description and their environmental assessments, the list of stakeholder and their requirements, the results from prioritization discussions, the lists of considerations for product improvements, the decision- making tools for new product design, the environmental communication templates, and other associated documents to each step.  
finally these results shall allow project partners to identify and describe concepts for (new) eco-designed products. the concepts shall not only be based on results of the method itself, but also include the inputs from the realization and testing of the eco-designed product concept at laboratory and pilot scales.  
the selection of compatible materials for separation, and the use of appropriate technologies to produce textile coverings are to be combined in such a way, that recycling of the products is possible and feasible and will allow new input stream into raw material pools (see figure 1).  
the environmental assessments for these new product concepts should be completed to compare the outcomes of applying the ecodesign methodology at the product level, i.e. before and after. furthermore one objective is the evaluation of the ecodesign methodology to confirm its applicability to different sectors and products.  
  
2.2. realisation of eco-designed textile floor covering  
the first evaluation step was realized in wp3 ârealisation of eco-designed textile floor coveringâ. goal of this work package was the development of concepts and prototypes of recyclable carpets on the basis of pa 6.  
in order to show that a circulation of the carpets raw materials (in this case basically pa 6) would be possible in future, the recyclability of the new designed carpet has been demonstrated. to achieve this, different aspects of the process chain have been considered.   
â¢ yarn production,  
â¢ production of woven and tufted carpet,  
â¢ development of possible recycling and logistic concepts.  
knowing the complex structure of textile floor coverings in combination with the different production methods is crucial for the understanding of the multiple individual tasks within the realisation phase.  
concerning carpets, a principal difference is made between tufted carpets on the one side (see figure 3 left) and woven carpets (see figure 3 right) on the other side.  
tufting is a widely-used technology for producing textile coverings. more than 60% of all textile floor coverings are produced by using this technology. during the tufting process, a pile yarn is tufted into the primary backing.  
afterwards, the tuft backing is coated in order to fix the pile and to provide it with a stable backing. the carpet used as benchmark for the area of the tufted carpets is the carpet tile heuga 727 sd produced by interface european manufacturing bv, scherpenzeel, netherlands (int). the particular aspect of those carpet tiles is that they can be produced in 50x50 cm pieces and can be laid loosely.  
for this reason, carpet tiles have to have a good dimensional stability (+/- 0.2% deviation). this aspect is very important for the relocation and the usage (e.g. cleaning) of the carpet tiles. it can be realised due to a heavy and stable backing from bitumen and glass.  
the idea is to have a separation between the polymer part (pile, primary backing and coating) and the bitumen part. thus, only the upper area of the carpet has to meet the requirements of a chemical recycling process.  
in contrast to the tufted carpet, a woven carpet (see figure 3 right) does not get a backing. the textile structure of the fabric has a sufficient dimensional stability with the help of a thin coating and therefore meets all the requirements.  
for this reason, it is the idea to implement the woven carpet in a form of a monomaterial carpet. benchmark for the woven carpets is taurus rips color sd of the company anker-teppichboden gebr. schoeller gmbh + co.kg, dã¼ren, germany (ank).  
  
2.3. evaluation of eco-designed textile floor covering  
after that the new concepts were evaluated within wp4 âevaluation of eco-designed textile floor coveringâ, which itself is divided into two parts.   
in the first part, semi-finished products will be analysed to give a continuous feedback to the development processes of the new carpet structures.  
the main objective of the second part is the evaluation of the final innovative (eco-designed) products, which should meet the quality requirements of the production chain and the demands of the health and safety regulations according to european and international standards.   
furthermore the results will be needed to compare the new concepts with the two benchmark products. additionally, it has to be found out if the laboratory tests used for existing commercially available products are suitable for classifying the eco-designed textile floor coverings developed within the project.  
being construction products, textile floor coverings are addressed in the eu-construction products regulation (cpr) which lists seven essentional requirements (er) for the products. these er are specified in detail in harmonised standards which are valid europe-wide. for resilient, laminate and textile floor coverings, the specific harmonised standard is en 14041. the description of the product and its application properties follow the specific product standards in which the classification requirements and the according test methods are set. for textile floor coverings, this product standard is en 1307.   
accordingly, a testing plan divided into four stages is designed in order to carry out the evaluation of the final products (see figure 4). the idea of the four stages is to give a fast feedback to the carpet developers about the properties of possible new materials and processes in a descending order.  
for example, if the new eco-designed products do not meet health and safety requirements, they are not to be tested further or if they do not pass the quality tests, they are not installed in the framework of the real-life testing (rlt). if a new product passes all four stages successfully, the goals of the eco-designed carpet are achieved.   
  
2.4. transfer of ecodesign methodology to other sector  
next to the construction sector the transport sector is used for the evaluation of the developed methodology. this is done in wp6 âtransfer of ecodesign methodology to other sector/productâ. the objective of this work package is to transfer the successfully applied ecodesign methodology for textile coverings in the construction sector to textiles in the transport sector, and to use it as the framework for a product innovation process.  
as such, one of the overall goals of the ecometex project is to develop and implement a versatile methodology which can be used for assessing various textile applications. at the end the project serves as a proof of concept, to understand the needs when adapting and using the methodology in another sector.  
in this case the product selected as reference is a coated textile luggage cover for automotive.  
the transfer to the second sector covers the full product innovation process, from the description and of the existing reference product, to the adaptation of all the templates for data collection, then the implementation of the steps of the methodology, leading to a new textile concept.  
likewise, the testing of this new concept, up to the production and evaluation of a prototype are part. finally, the adapted ecodesign methodology will be evaluated.   
  
project results:  
3. description of the main s&t results/foregrounds  
3.1. development of an ecodesign methodology for textile floor coverings  
the ecodesign methodology for textile floor covering developed in the ecometex project is structured in eight steps. the ecodesign methodology aims at improving the overall environmental performance of a reference product based on a comprehensive approach, as shown infigure 2. possible areas for improvement are derived from the results of the product environmental assessment (step 2), the stakeholder analysis (step 3), the process analysis (step 4), and the benchmarking of products (step 5). ecodesign tasks and ideas are derived from the identified possible improvement areas (in step 6). the ecodesign tasks are then translated into a new product concept (in step 7). lastly, an environmental communication instrument (step 8) is developed for the new product concept.   
templates for each step were developed, as well as the concept for a tool (in wp5) and a âcode of practiceâ. especially the data collection instruments build the backbone of the methodology, and these shall be used in the planning and in the application of the methodology, and in the collection of the real data on product and processes. the following sub-sections describe each step, to show the use and results of the methodology.  
the product description (step 1) is the framework that supports the following steps of the methodology, and contains relevant information on the product to be assessed. it is based on information from technical standards, descriptions of floor coverings, information from mandatory certifications and voluntary labelling schemes, economic, and environmental data. a template for the product description was developed, aiming at collecting the data in a structured manner, and with specific criteria and their corresponding connection (referencing) to technical data sources.  
two case studies were selected for the implementation of the ecodesign methodology. the first reference product is a woven broadloom carpet with 100% polyamide 6.6 (pa 6.6) pile fiber, meeting the requirements for heavy contract rating. the productâ´s weight is approx. 1.5 kg/m2. the yarn, weft, and warp account together for about 73% of the productâ´s weight, and the finish (backing) for 27% of the weight. the second reference product is a tufted tile of 100% polyamide 6 (pa 6) pile fiber, also for the contract market, with an average total weight of roughly 4.2 kg/m2. the yarn and primary backing account for 15%, the pre-coat for 20%, and the secondary backing for 65% of the productâ´s total weight per m2.  
the environmental assessment (step 2) deals with the description of the environmental aspects and impacts of the reference product over its entire life cycle. the goal of the environmental assessment in the ecodesign methodology was to calculate the global warming potential impact (gwp) using the web application ecodesign+ of the ecodesign company engineering & management consultancy gmbh, vienna, austria (eco) for the assessment of the product carbon footprint in kilograms of carbon dioxide equivalents (kg co2-eq). this software tool allows identifying the environmental hot spots of a product, with a reasonable modelling time. the functional unit used for the environmental assessment of the reference product is one square meter, with a service life of 10 years. for both products, the largest impact (gwp contribution) is resulting from the materials in the pile yarn. the second largest contribution is due to the energy consumption for cleaning the products during their entire service live, and in third place are the contributions from the manufacturing processes.   
the stakeholder analysis (step 3) aims at identifying important stakeholders and their concrete demands to be able to understand their requirements and further translate them into concrete technical parameters for product design. the different actors for textile floor coverings included the international bodies setting standards and labels, regulators, end customers, architects, contractors, carpet manufacturers, and post consumers (e.g., waste managing organizations). these stakeholders have a set of requirements which were identified and included for the analysis. the technical parameters influencing these requirements were also identified and displayed in a ârelationship matrixâ (quality function deployment matrix, or qfd). the qfd matrix shows the relationship between the most important technical design parameters and the important requirements form stakeholder.   
in addition, a sub-set of stakeholders was well assessed in more detail, namely specific types of customers for textile floor coverings. these might be, for example, customers mainly interested in the performance, or customers interested in the aesthetics of the products. the results of the stakeholder analysis show that the most important technical parameters in the case of the woven reference product are:   
â¢ the pre-coat material   
â¢ the mechanical yarn construction  
â¢ the construction of the product.   
for the reference tufted tile, the most important technical parameters are:   
â¢ the additive material in the pre-coat   
â¢ the pre-coat material itself  
â¢ the material of the secondary heavy backing.  
process analysis (step 4) focuses on the systematic quantification of key parameters of manufacturing and auxiliary processes and activities, to understand their associated environmental aspects and impacts. the process analysis for the manufacturing of textile floor covering comprises an input-output assessment, focusing on material and energy flows in the production chain. first, each single manufacturing step, and how it is connected in the manufacturing sequence, is defined and described. then, for each process, the input flows in terms of material (including the toxicity of materials) and energy inputs, as well as the output flows in terms of product, co-products, wastes, and emissions, are defined. the result from this process analysis is the identification of âhot-spotsâ, in other words, processes that need to be further investigated for improvement in terms of material efficiency, energy consumption, and/or toxicity issues.   
the energy consumption during manufacturing is a relevant issue for both reference products, especially in the finishing step, namely the process involving heat for drying the backing compounds of the textile floor coverings.  
the benchmarking of products (step 5) refers to the collection of information about âotherâ products such as competitor products, prototypes, and best available products. the objective is to assess how, and to which degree, these products fulfil specific stakeholder requirements when compared to the reference product. the benchmarking for the selected reference textile floor covering products show that most woven products are loop pile carpets containing polyamide 6.6 (pa 6.6) yarn. the total weight and pile weight show differences according to the different luxury classes. the reference woven carpet is the lightest product in this comparison. for tufted tile products, most contain a loop pile of recycled pa 6 (e.g., econylâ®). such products have a reduced (30% less) carbon footprint in the materials and production, when compared to products with virgin pa 6.   
the product and process improvements (step 6) summarize all significant results of the previous five steps, to identify a range of product and process improvement actions. improvement actions have been generated during âproduct improvement workshopsâ with project partners, where all results for each reference product were thoroughly discussed. the outcomes for the reference woven broadloom include a list of fourteen improvement measures, and for the reference tufted tile, ten measures. these measures range from new yarn compositions and new mechanical properties, to different pre-coat compositions, and alternatives for manufacturing using different technologies, for example those which allow pile fiber fixation without using additional components. in general the improvement measures fall into four categories or improvement strategies:  
1. improving the construction of the textile floor covering product  
2. improving the production processes  
3. prolonging the service life  
4. closing the loop of materials  
the identified improvement actions need to be assessed in greater detail and prioritized for putting forward a new textile concept (step 7). the criteria for the evaluation are based, for example, on benefits, effort, and risk of the proposed improvement action. ideally, the improvement actions with high benefit, low effort, and low risk will be taken into account. next to the evaluation of the improvement actions, the possibility to combine different actions was an important objective when formulating the new product concept(s). the improvement measures were prioritized and combined for the description of new product concepts or variations for each of the reference products. these measures were also proposed and selected to support the recyclability goals of the project, primarily looking at the material compositions, which allow physical and chemical recycling of the layers in the carpet.  
as part of the projectâ´s demonstration work, the industry partners produced a set of prototypes as in the technical realization part, considering recommendations from the methodology on a monomaterial and a separation layer approach using a pile of pa6. in this way, the complete carpet is designed according to the requirements of the pa6 depolymerisation process, so that it can be sensibly conveyed in a chemical recycling plant. the new tufted tile concept for example also includes a non-woven primary backing based on pa6. a coating composition allows the use of a separation layer for the tile. this facilitates the separation of the pile thread with its tufting medium and the carpet backing.  
the final step of the ecodesign methodology is to communicate the environmental performance derived from the implementation of prioritized measures for the product (and process) improvements to relevant stakeholders by means of the environmental communication (step 8). textile floor covering manufacturers are already using environmental product declarations (epd) for their environmental communications. epds according to iso14025 and en 15804 contain pertinent information to be communicated in the commercial sector. the edp provides information on products and on its environmental performance by using predetermined parameters, which comprise, among others, a sufficiently comprehensive set of impact category indicators. the information provided is credible, transparent, and structured in a clear way. it is verified by a third party and leads to reproducible results. therefore the epd is the recommended instrument for external communication with the contract (b2b) market, concerning the environmental impact of the new eco-designed textile floor covering in the ecometex project.  
after finishing the development of the methodology a customized tool should be set up. the developed customized tool concept can be seen as the repository of all the ecodesign methodology information and knowledge created and developed with and for the industrial partners in the project. the tool is sequentially structured like the eight steps of the ecodesign methodology (product description, environmental assessment, stakeholder analysis, process analysis, benchmarking, product and process improvement, new textile concept, environmental communication). the tool is realized as an interlinked pps-tool, and includes all templates of the methodology as downloads. these templates assist in the clear documentation of the relevant information, and in providing a comprehensive overview of the work.  
moreover the tool concept includes four specific ecodesign strategies for textile floor covering, in line with the ecodesign strategies in the software ecodesign pilot, ecodesign company engineering & management consultancy gmbh, vienna, austria. these strategies have been selected based on the results from the analysis steps, and based their relevance to support the product and process improvement step (step 6) of the methodology. these four ecodesign strategies for textile floor coverings are:  
â¢ strategy 1: improving the construction of the textile floor covering product  
â¢ strategy 2: improving the production processes  
â¢ strategy 3: prolonging the service life  
â¢ strategy 4: closing the loop of materials  
following the structure of the ecodesign pilot, each strategy contains a group of checklists. the idea is to use questions and examples to guide the user to think about alternatives for addressing the specific question and environmental issue. in this way, each checklist starts with an environmental assessment question, related to the priority of the topic addressed. the checklist then gives background information on the topic, as well as information on current research, specific knowledge, and examples from the ecometex project.  
the different strategies and their checklists have already been successfully tested during two in-house training workshops with the project partners ank and int. the checklists worked generated lively and creative discussions about additional product improvement ideas generated during the training.  
at the end of the project the ecodesign methodology as a whole was evaluated. this evaluation showed that the structured approach to analyse products from an environmental perspective is robust and clear. for selected steps the data collection efforts are rather high, and identifying product improvements and new product concepts needs the strong involvement of experts, particularly from industry. the application of the ecodesign methodology in the ecometex project has been completed for textile coverings in the construction sector, looking at woven broadloom and tufted tile carpets for contract use. the customized tool concept, together with the code of practice, is a compilation, in practical form, of the methodological approach and its specific results in the ecometex project.  
  
3.2. realization of the eco-designed textile floor covering  
as previously described there were three different approaches to develop a new textile floor covering structure:  
1. separation layer  
2. monomaterial  
3. material reduction  
within the project two different carpets were identified as reference products. the first one was a tufted carpet tile and the second one was woven broadloom carpet.   
  
3.2.1 tufted carpet  
a tufted carpet consists of several layers (see figure 3). the top half layer (thl) is a nonwoven (primary backing) and the pile material. the bottom half layer (bhl) is the secondary backing and consists of different materials like bitumen and some other filler. due to the fact that the tufted carpet consists out of several layers with different materials the use of the monomaterial approach was not feasible. therefore the separation layer approach was chosen. the idea was to separate the top and the bottom half layer from each other. furthermore it was the idea to use the monomaterial approach for the thl. this was due to the fact that a monomaterial thl can be better recycled after a possible separation process.  
current primary backings consist up to 100% out of polyethylenterephthalat (pet), which would cause a disturbance in the recycling process. to realise a monomaterial thl a new high pa 6 containing bicomponent yarn and fleece was developed. the new backing, which was developed within the ecometex contains only 60% pet and 40% pa 6.the main features were its very high strength after tufting and its dimensional stability at elevated temperatures. another main feature of this particular nonwoven was its recyclability, especially in combination with pa 6 tuft yarns. in this way it did not disturb the recycling process.   
for tufted carpets it is important to fix the yarns in the primary backing. concerning tufted carpets there should also be a good bonding between the top and the bottom half layer. in the project, two different approaches for the coating were used.   
one of the procedures was to melt off the yarns with the help of a calender roll. at the other procedure, the yarns were stuck with a polyolefin (po) dispersion.  
the novelty was that the layer for the fixation of the yarns could also be used to establish a separation layer between the thl and the bhl. at the calender technology, the separation layer was performed thermally reversible and at the coating with the polyolefin dispersion a thermally irreversible separation layer arises. in the following both techniques will be described more in detail.  
calender technology  
the individual process steps of the calender technology procedure are shown in figure 5.   
for the separation, the used carpet had to be heated up to only 100â°c. at this temperature only the separation layer softened, so that the bond between the top half layer and the secondary backing decreased and an easy separation was possible.  
next to the basic development of the separation layer, this technology was adapted to the special requirements of a carpet out of pa 6. this includes the reduction of the emission of caprolactam, which occurred due to the melting, the optimization of the dimensional stability due to the choice of thermoplastic binder and the equipment with permanent anti-static agents. concerning the equipment with anti-static agents, the whole carpet had to be considered, because otherwise an isolation layer occurred due to the fused yarns and the thermoplastic powder. it appeared that by an insertion of anti-static agents in yarns, primary backing and separation layer, a sufficient anti-static behaviour could be achieved. in the area of flame retardant, this technology, furthermore, showed good properties.  
coating  
the second separation technique was the thermally irreversible separation layer with a coating. the coating was done with a dispersion. however, the coating was based on a polyolefin dispersion, which did not disturb the recycling process. thereby, the dispersion was applied on the tufted primary backing and afterwards dried in an oven.  
the thermal irreversible separation layer was thereby realised through microspheres. it refers to small plastic beads which are filled with a propellant. at a heating point over a certain temperature, the gas expands and the beads extend to a multiple of their original size. due to this expansion, cracks occur in the dried dispersion and the layers dissolve from another. the effect mechanism is shown in figure 6.   
next to this basic development of the separation layer the processing parameters of the microspheres in the production process of the carpet tiles were also examined. thereby dependencies of the different separation concepts and the processing technology in the carpet production process were analysed.  
after that the carpets were manufactured in industrial plants. in the area of tufted carpets, several industrial attempts have been performed at int. a standard tufted primary backing was used and calendered at klieverik heli bv, oldenzaal, netherlands (kli), equipped with thermoplastic powder and combined with a glass fleece. afterwards, the product was equipped with a bitumen backing at the production plants at int. the resulting material showed good properties compared to the defined stakeholders. however, the binding to the se ...

# Islamicfashion

Project Acronym: Islamicfashion

programme & topic: FP7-PEOPLE FP7-PEOPLE-2012-IEF

Most frequent returning words in objectives:

* ('fashion', 23)
* ('project', 10)
* ('turkey', 9)
* ('research', 8)
* ('politics', 7)
* ('versus', 7)
* ('belonging', 6)
* ('dress', 6)
* ('industry', 5)
* ('conservatives', 4)
* ('debates', 4)
* ('addition', 3)
* ('seculars', 3)
* ('secular', 3)
* ('actors', 3)
* ('analyse', 3)
* ('practices', 3)
* ('ethics', 3)
* ('aesthetics', 3)
* ('headscarf-wearing', 3)
* ('presentation', 3)
* ('muslim', 2)
* ('westernisation', 2)
* ('neighbours', 2)

turkey, a predominantly muslim country, has long been described as being torn between 'western' and 'eastern' outlooks. it once embarked upon an ambitious project of voluntary westernisation and today is bidding for eu membership. however, in the last decade, an islamist-rooted party in power has shifted turkey's foreign policy towards the non-eu neighbours. in addition, the religiously conservative elite has sought to impose its version of modernity on seculars and religious conservatives alike. these changes have prompted new reflections on belonging in turkey and raised hopes for, or fears of, a more stable positioning between the âwestâ and the âeastâ.  
  
the islamic fashion industry represents an almost ideal site for analysing these politics of belonging. the concept of islamic fashion has been debated in relation to the dualities around which these politics are also articulated, such as un-veiling and westernisation versus re-veiling and islamicisation, the âwestâ versus the âeastâ, modernity versus backwardness, fashion versus religion, westernised dress versus islamic dress, fashion versus islamic fashion, or islamic dress versus fashionable islamic dress. in spite of these debates, the islamic fashion industry is a thriving sector, which attracts both religious conservative and secular economic actors, and responds to and nourishes the demand for fashionable modest dress.   
  
this project illuminates how these diverse actors deal with these conceptual controversies on a daily basis, and create and promote objects, images and ideas that objectify these politics of belonging.   
  
the project has the following objectives: 1) to investigate constants and innovations in the design of fashionable islamic garments; 2) to analyse debates about styles and trends in islamic fashion; 3) to analyse the institutionalisation of islamic fashion and the participation of secular and religious conservative economic actors; 4) to investigate practices of assembling fashionable islamic outfits and ways of discussing fashion and fashionable outfits; and 5) to analyse arguments for and against the existence of islamic fashion.  
  
the fieldwork was carried out for 10 months in istanbul, the researcher being affiliated to a prestigious local university, that is, bogazici university. the research involved different qualitative methods of data collection: (participant) observation in designerâs workshops and showrooms, in shops and open-air markets, and at fashion photo shoots, fashion shows, and boutique openings; semi-structured interviews and casual conversations with key players in this industry (e.g. fashion designers, fashion editors, boutique owners, fashion magazine owners); visual and content analysis of lifestyle magazines, fashion blogs, media and social media outputs; and internet research about modest clothing companies. in the second stage of this project, the researcher analysed her data, worked on publications and actively disseminated the outcomes of her fieldwork in invited talks in the uk and turkey, conferences and workshops in the uk and eu. in addition, she participated to and organised research and reading groups in her host department, attended research seminars and introduced her research to a wider audience.   
  
this research project reveals the complex intersections of politics, economics, ethics and aesthetics in the islamic fashion industry. the development of islamic fashion has generated material forms, stylistic innovations and sartorial practices that challenge ideological separations between modern/non-modern, western and eastern-influenced styles and practices. the main results of this project achieved so far are the followings: a detailed investigation of the development of islamic fashion in turkey; an innovative reading of the politics of belonging among the religiously conservatives through debates about the intersection of aesthetics and ethics in islamic fashion; a reconceptualization of belonging beyond the dualities modernity/non-modernity and secularism/islamism; a reconceptualization of gendered perspectives on entrepreneurship in a predominantly muslim society through a focus on the presence of headscarf-wearing entrepreneurs in the islamic fashion industry market; and a contribution to discussions on new subjectivities, youth and islam in contemporary turkey.   
  
relevant within and without the academia, the expected final result is a nuanced presentation of the intriguing phenomenon of islamic fashion, as it has developed in turkey especially in the last five years. this presentation will reveal the internal debates among the religious conservatives, in addition to the disputes between the seculars and the religious conservatives, about what it means to be modern yet pious, fashionable yet modest, conservative yet socially active woman in contemporary turkey. it will also introduce islamic fashion as a value project, which almost ideally supports the growing theoretical predisposition to consider value as a project of making, rather than simply something inherently material or immaterial. these results will be published in the form of an already contracted monograph at bloomsbury academic and minimum two articles in peer-reviewed journals. the wider societal implication of this project is illustrated in the following comments. one was prompted by a presentation of this project in ankara: âwe knew what the seculars thought about the headscarf-wearing women; we now learn how and why the religious conservative people distinguish between the different ways of veiling. we only saw the headscarf. you showed us the stylistic differences and the intersection of politics, aesthetics and ethics that they materialiseâ (an approximate quotation). another was prompted by my research: âwe now see the headscarf-wearing women on the street, we talk about them because of youâ (one of the researcherâ neighbours in istanbul, who defines herself as being a staunch secular). in brief, this research challenges existing perspectives on islamic dress and their practitioners, and enriches our understanding of the politics of belonging in contemporary turkey.

# THE RISE

Project Acronym: THE RISE

programme & topic: FP7-IDEAS-ERC ERC-AG-SH6

Most frequent returning words in objectives:

* ('project', 6)
* ('bronze', 5)
* ('isotope', 5)
* ('data', 5)
* ('copper', 4)
* ('strontium', 4)
* ('analysis', 4)
* ('samples', 4)
* ('number', 4)
* ('sources', 4)
* ('denmark', 3)
* ('italy', 3)
* ('ancient', 3)
* ('analyses', 3)
* ('indicate', 3)
* ('results', 2)
* ('textiles', 2)
* ('mobility', 2)
* ('adna', 2)
* ('europeans', 2)
* ('hungary', 2)
* ('profile', 2)
* ('range', 2)
* ('karin', 2)

erc summary report for the rise/kristian kristiansen  
the main achievements of the project according to thematic research blocs. results so far suggest highly organized international trade in textiles and copper, and corresponding human mobility during the bronze age.  
adna and strontium isotope analysis  
adna: morten allentoft and eske willerslev. a total of 526 teeth from bronze age europeans have been sampled, from sites across most of the european continent. these samples come from armenia, the czech republic, denmark, germany, hungary, italy, norway, poland, russia, and sweden. 290 samples have completed the dna screening phase of this project and data from another 160 samples will be ready by mid-july, 2014. the overall goal for the dna part of this project is to profile whole ancient genomes and genome-wide data from a large number of bronze age europeans. achieving this, will allow us to conduct a range of sophisticated genomic analyses, to illuminate the colonization of europe, and the ancestry and formation of the current european populations. our project is arguably the largest and most ambitious ancient dna project ever undertaken. it is unprecedented to profile 526 ancient individuals with next generation sequencing.  
strontium: doug price and karin frei and k.g: sjã¶gren: we have collected 524 samples for strontium, carbon, and nitrogen isotope analysis for this project. the data in general appear to indicate a good deal of mobility among the people of the late neolithic and bronze age. the large scale employment of 13c determinations on tooth enamel is unprecedented and will give new opportunities to discuss the complete diet, in contrast to the more conventional measurements on bone collagen which mainly indicate protein sources  
textile analysis  
karin frei: conducted a total of 90 textile-related strontium isotope analyses from the bronze age aiming at tracing the provenance of the textileâs raw material. the textiles were all retrieved within denmark. the preliminary interpretation of the results point to a high level of non-local raw materials, which may indicate that these raw materials where not locally available in denmark during this period  
sophie bergerbrant has done fieldwork/museum studies mainly in hungary at the settlement of szazhalombatta, exceptional for the site is the range and variation of the tools, indicating a very varied textile production from the finer to the coarser, from spinning to finishing, possibly embroidery.  
serena sabatini: case studies are carried out at the mycenaean citadel of midea, greece and the terramare village of montale, italy. here a considerable number of loom weights demonstrate the existence of weaving; however the most astonishing data are the number of spindle whorls. their number suggests that we are in the presence of a sort of âspinningâ community.  
lead isotope analysis of bronzes  
lene melheim: the combined interpretation of lead isotope and trace element data enabled us to identify several different source areas as well as chronological shifts in the supply of copper to scandinavia. in the period 2000-1600/1500 bc, analyses are consistent with central european sources or sources in ireland and the british isles. around 1600/1500 bc a marked shift in the supply of copper is seen. the best matches are found with ore sources in the western mediterranean, and mines in spain, sardinia and italy. this source is dominant for the next 500 years. from c. 1000 bc onwards, a greater variation is seen, with a substantial influx of copper also from the carpathians or the eastern alps.

# RETHINKTEX

Project Acronym: RETHINKTEX

programme & topic: FP7-PEOPLE FP7-PEOPLE-2013-IIF

Most frequent returning words in objectives:

* ('university', 9)
* ('textiles', 8)
* ('history', 7)
* ('revolution', 7)
* ('principal', 7)
* ('textile', 7)
* ('research', 6)
* ('public', 6)
* ('leeds', 6)
* ('investigator', 6)
* ('fellow', 6)
* ('industry', 6)
* ('project', 5)
* ('technology', 4)
* ('museum', 4)
* ('exhibitions', 4)
* ('change', 4)
* ('yorkshire', 4)
* ('work', 4)
* ('hahn', 3)
* ('manchester', 3)
* ('museums', 3)
* ('book', 3)
* ('school', 3)

rethinking textiles (rethinktex no 628722) was a two-year project funded by the marie curie people programme of the european commission. it drew on research methods in the history of technology to reinterpret the british industrial revolution. the project advanced the scientific understanding of this historical period among academics and disseminated new knowledge to a wider audience of students and the general public through publications, museum exhibitions, and conferences.   
  
the collaboration involved prof regina lee blaszczyk of the university of leeds as the principal investigator and dr barbara hahn of texas tech university as the fellow. the british mechanization of textile production is a crucial case for understanding the relationship between technological change and economic growth, but with few exceptions, the topic has long been dominated by economic historians concerned to explain change at the macroeconomic level. rethinking textiles is an example of micro-history, enriching the story of the industrial revolution with greater specificity about particular people, technologies, and products. it places the industrial revolution in an exciting new context, using the histories of technology, consumption, and design to develop a new narrative history of british industrialization as a global phenomenon with parallels to the digital age.  
  
in residence at the university of leeds between 1 july 2014 and 30 june 2016, dr hahn undertook significant historical research into technological change in the early modern and modern periods. she studied the economic, social, and cultural context that laid the foundation for the british industrial revolution with reference to the manchester cotton industry and the multiple varieties of yorkshire cloth manufacturing. the work entailed the study of documents and artifacts in libraries, archives, and museums in major centers such as birmingham, leeds, liverpool, london, and manchester, and in smaller towns around the uk such as derby and paisley. this work allowed dr hahn to develop a nuanced analysis of technological and social change in the british textile industry, reaching from the cotton importers of liverpool to the leisure trade of blackpool. the data-gathering activities of year 1 led laid the foundation for publications, exhibitions and, public programs in year 2.   
  
one of the major themes to emerge from the research includes a more complex understanding of the british textile industry, 1700-1900, and its role in the industrial revolution. in-depth research led the project team to see that âinventionâ and ârevolutionâ may not be the best concepts for explaining the major changes in the textile industry during the era of british industrialization. the fellow will develop this insight further as she refines an array of outcomes that include scientific journal articles, a monograph to be targeted to university students, a pamphlet for university teachers, and museum exhibitions. the principal investigator has already applied these ideas to her work on the yorkshire woolen industry and the fashion system, to be published as a book in 2017 under the auspices of her eu-funded crp, the enterprise of culture.   
  
the major outcomes of rethinking textiles were 1) the fellowâs presentation of 16 scientific conference papers and popular lectures, some of which have been revised for major international journals; 2) the drafting and refinement of the fellowâs 80,000-word book manuscript, tentatively called technology in the industrial revolution, under contract with cambridge university press for submission by 1 august 2017; 3) her negotiations with a publisher for a second short book, tentatively called cloth britannia: the history of technology and the industrial revolution; 4) her visits to nearly 30 museum in the uk and europe to study artifacts and promote the project; 5) a project website at the school of history, university of leeds; and 6) collaborations by the fellow and the principal investigator on public programs and exhibitions at regional and national museums.   
  
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further public engagement came through the university of leeds, where the principal investigator piggybacked rethinking textiles onto other research projects to create synergies. funding from rethinking textiles was used for two conferences on textile history, âwar of the fibresâ and ârethinking textiles: yorkshire edition,â which attracted 40 and 80 members of the general public, respectively. the principal investigator and the fellow both presented their work and served as moderators. another outreach efforts was an exhibition on âthe synthetics revolutionâ at ulita (the international textile archive at the university of leeds), which was curated by colleagues in the school of history and the school of design under the auspices of rethinking textiles and the principal investigatorâs large crp, the enterprise of culture.

# RETHINKTEX

Project Acronym: RETHINKTEX

programme & topic: FP7-PEOPLE FP7-PEOPLE-2013-IIF

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* ('technology', 4)
* ('museum', 4)
* ('exhibitions', 4)
* ('change', 4)
* ('yorkshire', 4)
* ('work', 4)
* ('hahn', 3)
* ('manchester', 3)
* ('museums', 3)
* ('book', 3)
* ('school', 3)

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# CROSSTEXNET

Project Acronym: CROSSTEXNET

programme & topic: FP7-NMP NMP-2009-4.0-7

Most frequent returning words in objectives:

* ('calls', 26)
* ('projects', 23)
* ('crosstexnet', 19)
* ('regions', 19)
* ('funding', 16)
* ('research', 15)
* ('joint', 13)
* ('impact', 10)
* ('project', 9)
* ('textiles', 8)
* ('proposals', 7)
* ('action', 6)
* ('plan', 6)
* ('call', 6)
* ('public', 5)
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* ('implementation', 5)
* ('textile', 4)
* ('companies', 4)
* ('document', 4)

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project context and objectives:  
the strategic objectives of crosstexnet were the following ones:  
  
(1) execution of four common calls for proposals for research in technical textiles;  
(2) coordination with other european r&d support initiatives in textiles like;  
technology platforms, specially etp textiles and other era-nets like leadera, manunet etc;  
(3) mutual enrichment of the regional/national r&d support programmes by fruitful  
interchange of experiences;  
(4) enlargement of the consortium, creating a notable platform to impact on european  
textile research.  
  
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project results:  
i. achievements:  
- crosstexnet has achieved an opening of regional research programmes after its completion as projects with partners from 9 (?) regions have been funded during the project.   
  
- the funding effect has been to mobilize 16 mln of public funding for research with a leverage of 25 mln including own contribution of companies and research organisations. this is small but relevant increase of total public r&d funding in textiles estimated at 150 mln euro (excluding financing of education).  
  
- this annual budget of 6 mln is also substantial compared to the around 15 mln a year of projects funded directly by the european union (fp7) or 5 mln a year funded through interreg iv-a.   
  
- in total 43 projects have been selected for funding, and 34 have been funded. this compares to 52 fp7 projects in textiles funded in that period. the number of partners in these projects is 134 of which 100 smeâs. this is also a significant number compared to fp7 projects.  
  
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ii. review assessment   
  
1. a joint strategy and programming process in place  
a joint action plan has been put in place (wp2). one of the result of the joint action plan has been to deliver a document serving as a thematic guideline for proposals and evaluation (deliverable 2.5). the document was also a reference document for (clusters of) companies and research centres in the partner regions in defining their regional funding and programming priorities. the programming of calls inside crosstexnet has not been limited by the technology road map resulting from the joint action plan (deliverable 2.6), since this would narrow the scope of the calls.  
  
2. a joint programme with financial commitment  
the joint programme has been underpinned by financial commitments of an average of 9 regions of the consortium by call. crosstexnet has facilitated 4 joint calls with the following participation in terms of regions:  
i. the joint programme has been limited to the funding of transnational calls, with proposals submitted by companies and research centres.   
ii. the programming has been enabled by thorough analysis of the doâs and donâts of an eranet and by a review of funding instruments and practices set up in other eranetâs.  
  
3. upgrading regional and national research funding policies - opening up of programmes  
several regions have gained knowledge about programming and funding without being able, for political reasons or for financial limitations, to participate in joint calls. seminars on best practices such as resulting from deliverables 1.5 and 1.6 have contributed to this.  
  
4. joint calls and funding of rtd-projects  
four calls of proposals have been launched, the fourth during a project extension. the projects funded do all fall in one of the pillars of the sra of the etp. sme involvement was a condition of funding in almost all regions participating in the call. hence the typical architecture of projects has been of smeâs from each participating region, complemented with a regionally based research centre.   
  
5. raising awareness of the importance of r&d and innovation in the textile industry  
the awareness of the importance of textile research and innovation has been raised in almost all participating regions (exc. slovenia and east-netherlands). for the latter region, awareness was already existing with a program for textiles inside high-tech materials and several national projects. slovenia was unable to be active in crosstexnet because of budgetary restrictions.  
  
  
potential impact:  
the impact of crosstexnet comes in four different components. two are connected to the participation into calls, either or not leading to funding and following up of projects. two are connected to the joint strategic action plan and to the implementation of policies in the regional context or an increase set of competences. partner may have grasped from 0 to 5 impact type of impacts in two categories:  
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2. implementation of regional policies. this impact applied in any case for regions involved in calls since it led to an activation of networks and implementation of funding. also many regions that were unable to participate into the call system of crosstexnet, reported an impact on either competences or on european awareness., leading up to implementation of policies in the 2014-2020 program period. participation in crosstexnet may also have led to more intense relations between public authorities, industrial operators and research centres.  
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# CROSSTEXNET

Project Acronym: CROSSTEXNET

programme & topic: FP7-NMP NMP-2009-4.0-7

Most frequent returning words in objectives:

* ('calls', 26)
* ('projects', 23)
* ('crosstexnet', 19)
* ('regions', 19)
* ('funding', 16)
* ('research', 15)
* ('joint', 13)
* ('impact', 10)
* ('project', 9)
* ('textiles', 8)
* ('proposals', 7)
* ('action', 6)
* ('plan', 6)
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* ('public', 5)
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# WEAR-A-BAN

Project Acronym: WEAR-A-BAN

programme & topic: FP7-SME SME-2

Most frequent returning words in objectives:

* ('antenna', 47)
* ('wear-a-ban', 36)
* ('software', 31)
* ('textile', 29)
* ('node', 28)
* ('figure', 25)
* ('scenario', 24)
* ('sensor', 21)
* ('technology', 20)
* ('project', 18)
* ('video', 16)
* ('nodes', 14)
* ('propagation', 14)
* ('wireless', 13)
* ('rehabilitation', 13)
* ('communication', 13)
* ('sensors', 13)
* ('developed', 13)
* ('specifications', 13)
* ('partners', 13)
* ('robot', 12)
* ('movement', 12)
* ('components', 12)
* ('electronics', 11)

executive summary:  
the wear-a-ban project is co-funded by the european commission through the "research for the benefit of specific groups" instrument in particular for the associations of small and medium sized enterprises (smes). wear-a-ban will contribute to enable ec policies such as ehealth for better healthcare in europe, i2010 for fostering better inclusion of disabled people through ict, elearning for speeding up changes in education and training, and eu health and safety at work for enabling safer interaction for machine or robot operators.  
the objective of wear-a-ban is to investigate and demonstrate ultra-low-power wireless body-area-network (wban) technologies for enabling unobtrusive human to machine interfaces (hmi) into sme-driven market segments of smart fabrics / interactive textiles (sfit), robotics for augmented reality assistance and rehabilitation, and natural interfacing devices for video gaming.  
the proposed research will generate high societal and market impact for the european smes, and will enable major technological breakthroughs in the areas of ultra-low-power radio system-on-chips (soc) and of textile-oriented system-in-package (sip) platforms for miniature wearable antennas, wireless and sensor electronics and digital signal processing.  
natural hmi will be enabled through the development of unobtrusive wearable sensor and wireless body-area-network (ban) communication concepts.  
the wireless technology required for ban-based natural hmi needs to be low power to operate from a very slim size battery, and miniaturised in order to fit into the strongly space-limited environment of smart fabrics / interactive textiles (sfit).  
today, wireless technology does not meet all of these requirements, and the major challenge of wear-a-ban is to improve the personal sensing capabilities with the use of unobtrusive, wearable long-lifetime ban through the following requirements for the wireless sensors:  
â¢ the motional and emotional sensor nodes must be ultra-miniature, in order to fit within very tiny/slim/thin embodiments amenable for embedding flexible sensors inside clothes,  
â¢ the wireless link must be ultra-low-power, for enabling multi-hour and multi-day autonomy using small and low-cost battery technologies,  
â¢ the antenna and radio must adapt to variable around-the-body propagation due to various placements on the body and movements of body parts,  
â¢ a high performance data-processing unit is needed to process sensor data, do data fusion of multiple sensors placed around the body and extract relevant features to be transmitted,  
â¢ the radio, antenna, sensors and digital electronics shall be integrated into a wearable system-in-package platform to allow flexible, unobtrusive and improved user experience.  
project context and objectives:  
the objectives of this innovative project was to investigate and demonstrate ultra-low-power wireless body-area-network technologies for enabling unobtrusive human to machine interfaces into market segments such as smart and interactive textiles, robotics for augmented reality assistance and rehabilitation and natural interfacing devices for video gaming. wear-a-ban enables major technological breakthroughs that will generate strong societal impact by increasing the comfort, health and security for a wide category of users in the european population.  
communication between man and machine, also known as human-machine-interface (hmi), could become more intuitive or natural by integrating motional and emotional information, parameters which are difficult to express with standard hmi devices. indeed, in man to man communication, a large part of the information is transmitted naturally through non-verbal communication (body language, intonations, etc). such a paradigm shift requires a move from classical computer peripherals towards natural interfaces that mimic the natural human interaction. with recent advances in microelectronics, embedded signal processing and software technologies, more natural hmi solutions are within reach, which will enable new gaming, medical rehabilitation and robotics interfacing paradigms and require very short and intuitive learning curves for anyone.  
the wear-a-ban project, with the active participation of the consortium members, consists of leading research organizations, universities, associations of smes and sme participants from all over europe, including the robotics society of finland, cap digital paris region, ateval, ramon espi s.l., movea sa, deltatron oy, wizarbox ltd., signalgenerix ltd., voxler, aitex, csem sa, technical university of berlin, vtt, cea-leti and the coordinator rtd talos ltd.  
wear-a-ban will enable major technological breakthroughs in the areas of ultra-low-power radio system-on-chips and of textile-oriented system-in-package platforms for miniature wearable antennas, wireless and sensor electronics and digital signal processing, resulting in significantly increasing the competitiveness of the sme associations participating in the project.  
create a network of smart sensing nodes around the human body was the goal of this wear-a-ban project. starting from smes requirements, a wearable node has been fabricated, the elementary bricks are:  
â¢ dedicated ultra-low-power rf system-on-chip based on its icycom technology, with best in class rf power consumption as well as on-chip digital signal processing and power management.  
â¢ off the shelf sensors like magnetometer, accelerometers, gyroscopes and microphone.  
â¢ textile antenna  
â¢ embedded software including sensing management and network ultra-low power rf protocol.  
this electronic node of 2x3 cm2 is then used either into the textile antenna (motional node, to left image with opened textile antenna) or into the headset for audio features (emotional node, right images). (see figure 1: textile antenna including the wear-a-ban electronics.)  
  
the performances of the node and its antenna are proven to be sufficient to create a sensor network, working on small coin cells. and when integrated into textile, the network is human wearable, allowing precise movement detection (smart node allows some data pre-treatment on board.).  
four scenarios have been set up by smes in order to show the utilisation of the ban in real applications. the main achievement in this project has been the final demonstrators of four different application scenarios demonstrating the viability and versatility of wear-a-ban technology.  
integrating the developed body area network (wab nodes) into textiles, the connexion among them and the different specifics software and the right treatment of the obtained information, wban technology has been able to monitor the human activity at home; to show the right rehabilitation movement in injured limbs; and goes beyond the current state of gaming interfaces allowing, without cameras, play video games by means of legs and arms movement in real time.  
\* wear-a-ban based sfit demonstrator:  
when looking at results that demonstrate the usefulness of creating intelligent textiles that help in the realistic monitoring of movement, it is important to bear in mind garments that have already been developed and integrated into each scenario and form part of the overall project demonstrators. (see figure 2: wrist, ankle bands, sleeve, and garments details.)  
all of these garments, regardless of the scenario, have been designed to be washable throughout their life cycle (which could be years), even after each use (which is recommended). this includes the flexible pockets containing the nodes and which need to be easily removed before each wash, as well as the material type and its components which may have been altered slightly to adapt to each scenario.  
the gaming demonstrator combines basic leg and arm movement monitoring with real-time synchronization to play a video game; it includes a microphone for voice control. the use of intelligent textiles in this case has centred on the development of wrist and ankle bands that can accept the integration of the wab modules and antenna to avoid the need of wearing special clothing for game control that cannot be exchanged between players easily. the garment itself is the controller and can be worn comfortably, avoiding the need for hand-held controllers. the system is velcro-fixed to allow easy removal.  
\* wear-a-ban daily life activity monitoring demonstrator:  
there were two main objectives to achieve in this scenario through the demonstrators:  
â¢ energy expenditure control  
the services presented in this scenario are proposed during daily activity of a person. energy expenditure (ee) is an important indicator to assess if a person has physically solicited enough his body during the last days or weeks.   
one of the functions provided in the scenario is the ee spent by a person wearing the sensors. as we are using motion sensors (no heart rate sensor), the device is only supposed to measure mechanical energy.  
â¢ physical activity recognition (see figure 3: main activities in daily life.)  
the technological developments can be concluded that are successful regarding the scenario requirements: integration of many challenging components has been done entirely. the on-body node is flat, and flexible enough to make future product design credible and possibly integrated in the textile. radio circuit and protocol is highly flexible. it is not just a piece of hardware, itâs also a kit, a platform to produce new product scenario. the range of the radio/antenna was not an issue for the scenario, since to implement two modes had been decided: a recording mode and a radio mode (when the user is back home).  
a video featuring the daily life activity monitoring demonstrator is available at: http://www.youtube.com/watch?v=sg503z-szy0&feature=bfa&list=plash6daifspv5ktfxdztlc1-1rago7cvw   
   
\* wear-a-ban gaming demonstrator:  
the services presented in this scenario are proposed during playing a music video game. music video games and especially singing or dancing video games let the players interact with their favorite music and have fun. the wab network is capable to send motional and emotional data to the video game in order to establish dancing and singing scores. it provides a compact unobtrusive interface that the player can use seamlessly, so that playing the video game in a natural interface.  
most music video games are based on comparing the performance of the player with a reference performance. in the case of a singing or dancing video game, the playerâs performance is compared with the singing of the reference singer and the dancing of the reference singer. (see figure 4: dance and sing game screen shot.)  
a headset coupled with a motional sensing network, worn in simple clothes let the player completely free to dance and sing. the realization of the game shows:  
â¢ integration of many challenging components has been done entirely both for the motion sensor and for the microphone. the on-body node is flat, and flexible enough to make future product design credible and possibly integrated in the textile.   
â¢ the range of the radio/antenna is not an issue for the gaming scenario, since the distance between the player and his tv is limited to a few tens of meters.  
a short video has been prepared about the gaming demonstrator which can be accessed at the link:  
http://www.youtube.com/watch?v=bckh28dth9m&feature=bfa&list=plash6daifspv5ktfxdztlc1-1rago7cvw   
  
\* wear-a-ban robotics-for-rehabilitation demonstrator:  
the purpose of this task was to validate the performance of the wear-a-ban nodes network in a medical scenario. this scenario was dealing with robot based rehabilitation of stroke patients.   
robo and delta developed the concept with the guidance of rehabilitation professionals at the kuopio university hospital. the concept was designed in cad-environment and especially the connection to the upper limb of the patient was in focus. the concept is designed using the most potential robot arm type lwr by kuka roboter ag, germany. this robot type has 7 degrees of freedom, allowing the robot to reach the patient from different angles in order to avoid possible collision between the robot arm and the patient. the safety aspects are taken into account by allowing the robot run only within safety speeds. the robot also reacts to collisions by withdrawing by control system means, thus making the physical contact more ânatural with human body. (see figure 5: the rehabilitation scenario in real scale with the use of the slim industrial robot.)  
  
the conclusions of this task show this scenario has in reality a good potential of this developed wireless technology in the vicinity of human body. the limb movements can be monitored and various product concepts can be generated based on this wear-a-ban technology. the potential end- users of this robot based rehab scenario are interested to further develop and test-run the robotized rehabilitation concept. the developed technology has now been proven to work in this environment.  
robo and delta tested the developed sensor nodes against the rehab application specs. the video material is available at:   
http://www.youtube.com/watch?v=-ozy-jh6n6a&list=plash6daifspv5ktfxdztlc1-1rago7cvw&index=1&feature=plpp\_video  
the simulation video on the robotics scenario with the mirror therapy concept, developed by robo and delta, is available at: http://www.youtube.com/watch?v=xsaunlesrnm  
project results:  
the technical work has been decomposed in specific workpackages (wp) with the following work:  
\* wp1 user requirements and specifications:   
the work performed within wp1 was completed during the first year of the project. driven by the end-user smes, four use-case scenarios were identified and described, namely âscenario 1: robotics based rehabilitationâ, âscenario 2: wear-a-ban based sfit in a garmentâ, âscenario 3: daily life physical activity monitoringâ and âscenario 4: wear-a-ban based gamingâ.  
within the description of work a total of three tasks with five deliverables were defined for wp1:  
â¢ t1.1 for the collection of user requirements for the 4 demonstrators and market needs. this task had d1.1 as a deliverable with the definitions of 4 demonstrators.  
â¢ t1.2 for functional specifications definitions with 2 deliverables: d1.2.1 for draft specifications (functional specifications derived from the scenarios) and d1.2.2 for the final version.  
â¢ t1.3 for technical specifications definitions with 2 deliverables: d1.3.1 for draft specifications (detailed technical specifications for the technology bricks) and d1.3.2 for the final version.  
the description of work defined four main markets with strong commercial potential for the technology to be developed by the wear-a-ban project, namely:   
â¢ scenario 1: robotics  
it describes the requirements and high-level specifications of a robotics man-to-machine application. these are of interest of sme-ag robo and sme delta participants from finland. it is foreseen that the rehabilitation of an injured arm or leg is conducted at home/medical center with the help of a rehabilitation robot based on the forced rehabilitation (extra power is brought to conduct the exercise by the robot).  
â¢ scenario 2: smart fabrics and interactive textile  
the textile end-users sme-ag ateval and rapife have envisioned to embed movement sensors in a shirt and/or pants for detection of maximum amplitude of joints movements in patients in rehabilitation. the main markets will be sports and military quality textile-based equipment.   
â¢ scenario 3: health  
it is based on a âdaily activity monitoringâ concept by movea and sme-ag capdigital, which comes in the form of a patch that would be applied to a patient for long duration motion monitoring (motionpatchâ¢). the users of the monitoring system are the medical teams, the patients or the persons that wears the patch. the goal is to get a continuous and consistent motion data information during daily life.  
â¢ scenario 4: gaming  
it is driven by playall/wizarbox and sme-ag capdigital, and combines all movement detection and emotional voice sensors. the voice analysis sensor will analyse the singing performance and expressivity of the players, and speech recognition will be implemented additionally to manage the complete interface of the game prototype (no gamepad required to navigate menus, select songs, etc.). movement sensors will be used to classify dance movements of a player. when all combined we can create a singing and dancing game with merged scores.  
the main results were thus the specification of the use-cases, the technical specifications to enable to launch the technology developments in wp2 through wp6, and the specifications of the demonstrator prototypes for wp7.  
  
\* wp2 radio and dsp ic:  
the main tasks in wp2 concerned first the delivery of csemâs existing icycom platform to the partners for launching the software developments, secondly to design, fabricate and characterize the wear-a-ban system-on-chip (wab soc), and thirdly to provide the partners with a baseline low-level software abstraction layer destined to support the software running on the icyflex1 embedded processor, managing the on chip components.  
the main deliverables were:  
â¢ d2.1: wab system on a chip (soc)  
the delivery of the pre-existing icycom platform allowed the partners to start their own technology developments in the meantime of the design and fabrication of the wab soc. as the latter uses the same icyflex1 dsp as icycom, the wab software development could be launched efficiently by cea and sg once the target specifications from wp1 were available. csem provided icycom samples, the icycom hardware and software development kits, and training to the partners.  
the development of the wab soc started with the establishment of the wab soc specifications, starting from the technical requirements from wp1. in particular, it was confirmed that a large part of the existing icycom background could be re-used for the targeted use-case demonstrations. three main additional functionalities tailored for wear-a-ban were also specified, firstly concerning the wab soc radioâs power amplifier (pa) with reduced output power and consumption, secondly the antenna tuning mechanism using a capacitor bank for allowing to compensate antenna de-tuning artefacts for optimal propagation, and thirdly the digital pdm (pulse-density-modulation) peripheral to be used with a microphone for the emotional sensor (a new microphone arrived in the meantime is simply accessible through standard i2s).  
the final hdk and associated hal have been successfully provided. figure 6 shows the jtag\_extender (on the left), plugged into the battery holder of the daughter card (below the white square marked â238â is the wab chip). this battery holder has been re-used for the wab node, and this kit is directly used as base station of the ban, on the pc side. (see figure 6: hardware development kit (hdk).)  
this chip has been successfully designed, fabricated, tested, and delivered to partners. it is fully functional. furthermore, industrialization of that chip has been proposed to end users.  
â¢ d2.2: low-level software library, to give a simplified software access to the wab soc  
the development of the baseline software library was also launched and completed efficiently by csem. this piece of software allowed the other partners (mostly cea, sg, voxler) developing the applicative layers of the wear-a-ban software without needing to code at very low-level, thanks to the usage of a developed hardware abstraction layer (hal) specific for the wab soc.  
this software piece has been provided and maintained all along the project. it is available on a centralized server (sub-version) at csem. all partners and end users have used this server to share theirs software developments.  
  
\* wp3 antenna and propagation:   
the main tasks in wp3 have been to assess propagation in wban context, perform the preliminary design of antenna prototypes, and design the tuneable antenna interface. the work in wp3 was conducted in close interaction with the partners in charge of sip in wp5 (tub and aitex) and with wp2 for the interfacing aspects from antenna to wab soc (csem).  
the main deliverables were:  
â¢ d3.1: propagation reports  
â¢ d3.2 and d3.3: miniature tuneable antenna reports.  
in the first year, the textile antennas were tested with dummy electronics inside the antenna. also preliminary propagation testing was conducted with textile antennas and rather large and bulky vtt data logger. in the second year, textile antenna and on-body propagation testing was carried out, totally wireless propagation measurements were carried out with actual wear-a-ban electronics implemented inside the antenna and specially designed propagation testing software. no disturbing cables of objects were thus in the vicinity of the antenna. the testing was carried out with both versions 1 and 2 of the wab chip.  
first, the frequency sweep tests were conducted in order to fine tune the antenna interface and verify the textile antenna gain. next propagation on different movement scenarios and environments were tested. the results were good: about -50 to -60db links were recorded in all the scenarios, which leaves 20db margin in the wear-a-ban link budget -80db. also, in the free space at least 5m distances could be achieved in all the movements and antenna locations, even if the antenna was shadowed by the person or there were some indoor walls. in addition, channel modelling was conducted with the measured on-body propagation data. the links could be well described with nakagami distribution.   
in addition to the textile antenna, headset node antenna was designed, implemented and tested in wear-a-ban scenarios. in all the scenarios from -53 to -73db links were recorded, which fit well within the link budget. in figure 6, the textile monopole antenna as well as the headset node monopole made out of flexible copper foil are presented. (see figure 7: textile antenna including the wear-a-ban electronics.)  
the main results are first, that a comprehensive propagation study was conducted, and allowed identifying two best-suited antenna approaches (vertical loop and monopole) with conclusions about propagation characteristics vs antenna parameters. secondly, two antenna structures (vertical loop and monopole elements above the ground plane) were optimized, implemented in textile and measured, leading to very promising path loss measurement results. thirdly, a specific antenna tuning structure was designed within the wab soc (jointly with wp2) and includes the schematic for the impedance matching between the antenna and the radio front-end.  
  
with the achievements cited above, the next step has been to put the different pieces together (antenna in textile & wab soc & wab module) and run propagation tests in order to fine-tune and adjust the antenna characteristics for the final version.  
\* wp4 sensors and communication:  
the main tasks in wp4 consisted in development of the hardware and software technology bricks for the sensor signal processing, and software technology brick for the wireless communication.  
the main deliverables were:  
â¢ d4.1: node design and sensing embedded software  
concerning the sensor signal processing, the main results were the following: the icycom platform was efficiently delivered by csem and used by sg to realize the first sensor signal acquisition hardware as an add-on board. the on-the-shelf sensors were identified for the motion sensing platform (accelerometers, gyrometers and magnetometers) and for the emotional sensing platform (voice processing using a microphone). first pieces of software were also written for supporting the proper link with the pre-existing icycom hdk (ultimately with the wab soc). (see figure 8: first prototype assembly; figure 9: details of the first prototype sensor board.)  
  
following these first steps, the design of the generic wab node was started, and the wab nodeâs pcb was fabricated and will embed the motion sensors, the wab soc and the battery holder plus the rf interface to the antenna. the following figure shows the equivalent hardware to the first prototype assembly. (see figure 10: wab node electronics with jtag\_extender plugged into the battery holder.)  
this wab node electronics has been the base brick of the motional (see wp5) and emotional nodes. (see figure 11: emotional wab node.)  
the corresponding embedded software, based on the hal has been provided in library format on the svn server. it is divided into three categories:  
â¢ sensor interface/communication (see figure 12: sensor interface and communication software blocks.)  
â¢ data processing (see figure 13: data processing software blocks.)  
â¢ mac (see next section).  
  
â¢ d4.2: embedded mac protocol software (rf network)  
concerning the wireless communication software, the main results were the following: the custom mac protocol has been defined and will be based on the tdma access scheme. it is well suited to the star topology with a central node of most ban application and scenarios and among them those of the wear-a-ban project. a preliminary implementation of the mac protocol was also started, and is currently made available to the other project partners.  
the next step has been to take these pieces and combine them with the wab soc and wab module. this allowed fine-tuning, testing, characterizing and finalising the sensor and communication technology bricks for wear-a-ban.  
the corresponding embedded software is available on the svn server, as library. (see figure 14: mac software blocks.)  
\* wp5 miniaturized packaging:  
the main tasks in wp5 consisted in developing the sip (system in package) platform first for the electronics components assembly (electronics sip) and secondly for the assembly with the textile antenna (textile sip).  
wp5 is a critical workpackage in the sense that it is a âsystem integrationâ package which needs to collect and iterate around individual technology bricks delivered by the other wpâs. wp5 triggered intensive cooperation among the sip partners (tub, aitex) and the other partners for the antenna (vtt) and the wab module (sg, csem, cea), and has delivered very interesting sip solutions.  
the main deliverables were:  
â¢ d5.1: sip modules  
â¢ d5.2: textile antenna sip  
the main results are the following: a strategy for designing a removable textile node was devised, and an elegant first design was realized. this design proposes to realize a textile antenna which is folded on top of the wab node. this concept was validated using dummy modules in anticipation of the final wab node, and the study included the definition of the manufacturing process having in mind industrialization. (see figure 15: textile, bendable and lightweight uhf antenna attached to the module.)  
  
during the second part of the project wab nodes have been assembled with real electronic and successfully tested (bending, humidity etc.). the reliability tests (temperature cycling, steady state temperature humidity test, and bending) have shown that the assembled nodes resisted all kinds of applied stress. the antenna soldering shows very good results and reliability.  
the final task within this work package concerned the emotional (headset) node. to realize the emotional node the same electronic module has been used. additionally, a small microphone pcb was developed. the microphone pcb consisted of the microphone, one pull-up resistor, and one capacitor. (see figure 16: microphone pcb.)  
  
\* wp6 wban platform integration:  
this wp was responsible for the realization of the ban prototype and the validation at system level that the co-integration of the technology bricks - wab hardware, software, sip - delivered from the previous wp's enables to realize the foreseen ban concepts.   
the first objective has been to embed the wear-a-ban soc (wp2), the compact antenna (wp3) and the signal processing software (wp4) onto three selected platforms prototype using the sip assembly technology (wp5).   
the second objective has been to do the laboratory-level performance evaluations of the wear-a-ban prototypes.   
the last main objective has been to provide wp7 with the core building blocks of unitary components for further integration and test in modules within wp6. also wp6 has checked that the current wear-a-ban module mock-up satisfies the smes and sme-ags.  
the main deliverables was:  
â¢ d6.1: embedded software validation for the wab node  
â¢ d6.2: validation and test of the textile antenna  
â¢ d6.3: body area network validation  
wp6 has to get all unitary components from:   
1. wp2 for the radio chip and the low layer hardware.  
2. wp3 for the textile antenna and the radio-antenna matching interface module.  
3. wp4 for the sensor modules, sensor processing functions and the communication protocol stack.  
4. wp5 for the module and textile antenna assembly and packaging.   
to be able to build the four project demonstrators in wp7, several components need to be integrated together.  
moreover, wp6 partners have checked that the foreseen wear-a-ban module mock-up and components comply with the end-user smes and sme-ags requirements and expectations, by both cross-checking the wp1 specifications and by a specific workshop.  
four types of wear-a-ban nodes have been defined:  
â¢ the central node or hdk wab v2 daughterboard  
â¢ usb jtag extender to program the node (see figure 17: hdk wab v2 daughterboard with jtag\_extender.)  
â¢ wab nodes v2 with textile antenna (see figure 18: wab node v2 with textile antenna.)  
â¢ wab headset v2 (see figure 19: headset v2 with microphone.)  
all final wear-a-ban nodes have been distributed to partners, in order for them to develop the final demonstrators.  
a view of the communication protocol stack components is given on the figure below. the communication protocol is composed of low level hardware drivers, an abstraction layer to make the upper layers as much independent on the actual hw implementation as possible, a medium access control which forms the core part of the networking protocol, a link layer control to convert and arbitrate application data into data flows with different qos requirements and profiles to implement the end user application requirements in terms of network topology, sensor use, etc. (see figure 20: communication protocol stack components for the wear-a-ban module.)  
  
\* wp7 wban testing and end-user validation:  
the main goal achieved in this work package, has been the final demonstrations in the development of four different application scenarios for demonstrate the viability and versatility of wban technology.  
in this way, through integration of the developed nodes into textiles, the connexion among them and the different specifics software and the right treatment of the obtained information, wban technology has been able to monitor the human activity at home; to show the right rehabilitation movement in injured limbs; and goes beyond the current state of gaming interfaces allowing, without cameras, play video games by means of legs and arms movement in real time.  
in order to achieve those objectives, four scenarios demonstrators were planned to be developed. each demonstrator represented one task in the project.  
â¢ task t7.1: wear-a-ban based sfit demonstrator  
when looking at results that demonstrate the usefulness of creating intelligent textiles that help in the realistic monitoring of movement, it is important to bear in mind garments that have already been developed and integrated into each scenario and form part of the overall project demonstrators. (see figure 21: wrist, ankle bands, sleeve, and garments details.)  
all of these garments, regardless of the scenario, have been designed to be washable throughout their life cycle (which could be years), even after each use (which is recommended). this includes the pockets containing the nodes and which need to be easily removed before each wash, as well as the material type and its components which may have been altered slightly to adapt to each scenario.  
the morphology of each pocket has also been studied, resulting in the design of flexible pockets which mold themselves to the node to hold it firmly in place; this includes the velcro-closed flaps that protect the device but allow it to be easily removed. involvement in the daily life activity monitoring demonstrator has required the development of two types of garments. a polo shirt that has an unobtrusively-integrated wab node on the lower side which guarantees that the type of exercise the wban wearer is engaging in will be faithfully recorded, including the position o ...

# I-PROTECT

Project Acronym: I-PROTECT

programme & topic: FP7-NMP NMP-2008-4.0-9

Most frequent returning words in objectives:

* ('system', 55)
* ('rescue', 36)
* ('sensors', 35)
* ('modules', 34)
* ('project', 33)
* ('protective', 28)
* ('communication', 28)
* ('sensor', 28)
* ('developed', 27)
* ('activities', 24)
* ('rescuers', 24)
* ('end-users', 24)
* ('integration', 23)
* ('monitoring', 23)
* ('development', 18)
* ('chemical', 18)
* ('temperature', 18)
* ('requirements', 18)
* ('module', 16)
* ('unit', 15)
* ('results', 14)
* ('clothing', 14)
* ('parameters', 14)
* ('materials', 14)

executive summary:  
   
this report presents results of research activities focused on the development of a new generation of intelligent personal protective systems dedicated for fire-fighters, mine rescuers and chemical rescuers. the systems address the needs and demands of these target rescuers as they may be exposed to various hazards and high-level risk. the core of the systems includes integration of protective clothing with various sensory modules for real-time monitoring of selected physiological parameters of end-users and monitoring external environment parameters during rescue activities, such as toxic gases, oxygen deficiency and temperature. a crucial and inseparable component of the system is the communication network which ensures that all monitored data related to health status of the end-users as well as to the rescue environment are transmitted wirelessly to the developed rescue coordination centre (rcc), where they are adequately visualized. the integral part of the project also included the development of the use of specific properties of nanomaterials for improvement of functionality and safety of the elements of the system.   
  
all the safety and usability parameters of the new ppe systems were tested in the laboratory conditions prior to field trials performed with human test subjects. the basic aim of the tests was to assess a functioning of each individual element or sub-module as well as protective properties of protective clothing after its integration with the sensors and communication units. evaluation of the reliability of the integration of each individual system modules were undertaken with regards to end-userâs safety and comfort of use (ergonomics). moreover, the information displayed in the rcc workstation for the rescue operator was evaluated by the end-users for its legibility and quality.  
  
the interdisciplinary character of the project allows for the achievement of scientific and technological objectives leading to measurable and verifiable prototypes and models i.e.:  
  
1. new design of underwear with embedded newly developed sensor module for monitoring physiological parameters of the end-users joint with monitoring unit and power source,  
2. new modular design of environmental sensor module measuring concentration of various selected gases and external temperature,  
3. new communication module for wireless transmission of data monitored by the sensor modules,  
4. new design of protective clothing for fire-fighters and working clothing for mine rescuers adjusted for integration with environmental sensor modules,  
5. portable station of rescue coordination centre with application for visualization of data from the sensor modules, personal data related to the rescuer and the current status of breathing apparatus,   
6. new communication unit (so-called personal digital assistant) responsible for ensuring data transmission between sensor modules and the rcc,  
7. model of fabrics with antielectrostatic properties,  
8. model of conductive paths based on nanomaterials for passing through of an electric current,  
9. model of chemiresistive film based on nanomaterials for detection of toxic gases.   
  
as a result of the project relevant recommendations for further improvement of all developed ppe system elements were defined as well as manufacturing concept was proposed. the project outcomes were disseminated and promoted at various national and international events including conferences, workshops and trade fairs for the target end-users: fire-fighter, chemical resuers and mining rescuers.   
project context and objectives:  
the main objective of i-protect project was to develop an intelligent personal protective equipment (ppe) system that would ensure active safety and health protection as well as information support for personnel in high risk and complex environments, in particular for chemical rescue teams, fire-fighters and mine rescuers, who are exposed to such factors as fire, explosions, high temperature, dangerous toxic substances, limited visibility, high humidity and a limitation of breathable air.   
the overall goal of the project was related to the integration, within the new ppe system, of state-of-the-art materials, optical fibre sensors, gas and temperature detectors, and ict solutions as well as to the development of innovative materials (based on nanotechnology) and their integration with ppe elements in order to enhance multi-functionality and adaptability. the approach also included ensuring ergonomic design of the new ppe system as well as validation of its functionality, safety, comfort of use and performance level by practical performance tests in conditions simulating real rescue activities.   
there were 4 main phases of the project, i.e.: 1) conceptualization, 2) technical development and integration, 3) verification and validation and 4) dissemination and exploitation.   
the 1st phase included one work package - wp1, the 2nd phase included five work packages - wp2, wp3, wp4, wp5 and wp6, while the 3rd and the 4th phases included work packages wp7 and wp8 respectively.   
phase 1 â conceptualization  
within this phase the activities of wp1: identification of end-users needs and defining technical requirements were performed and the overall concept of the i-protect ppe system was elaborated. the project partners specified collectively all technical and usability specifications for multifunctional ppe system for fire-fighters, chemical and mine rescuers. based on the analysis of the most common and hazardous rescue scenarios as well as needs and demands reported by the representatives of the end-users, who actively participated in the project, relevant variants of the ppe system solutions were proposed. all requirements and needs were collected and analyses, which was the basis for elaboration of guidelines and technical requirements for each separate module as well as for the whole ppe system to be developed within the project.  
phase 2 â technical development and integration  
within this phase each separate module of the ppe system was developed and then initially integrated to check its compatibility and functionality with the other elements of the system and in order to create a complete homogenous ppe system.  
the 1st main component of i-protect ppe system i.e. module for monitoring heart rate, breathing rate and body temperature was developed within wp2: sensors for monitoring physiological parameters. the concept of monitoring health status was based on the use of fibre optics. selected optical fibres were integrated with technical textiles and then with the textile material of the underwear adjusted to the human body. optical fibres responsible for measurement of the breathing rate react to the movement of the chest of end-user during phase of inhalation and exhalation. optical fibres responsible for measurement of the body temperature react to changes of the temperature of the body surface.   
the first prototypes of the physiological sensor modules were tested for their elasticity and for the performance in various temperatures and humidity. small portable monitoring units to control the measurements of physiological parameters of the rescuers were designed and developed. these both elements of the physiological sensor module jointly with dedicated power source were integrated with the special underwear dedicated to the project target users.   
the 2nd component of i-protect ppe system i.e. environmental sensor modules for monitoring various toxic gases and external temperature was developed within wp3: sensors for monitoring environmental parameters. according to the needs specified by end-users the most important gases from the point of view of their occurrence during the rescue activities and toxicity were selected to be measured by the sensor modules: carbon dioxide and monoxide, methane, chlorine, ammonia and hydrogen sulphide. moreover the detector for measurement of oxygene content was used in order to monitor oxygen deficiency in the breathable air. sensing properties of detectors chosen from the market were enhanced by the development of dedicated electronic modules. relevant adjustment/calibration of the sensor modules to correct their functionality in rescue conditions i.e. detection limits and response time were carried out.   
a special enclosure for the detectors dedicated to protect the electronic circuits and power source was also developed. the modules were integrated with protective garments textiles by means of placing them in custom-designed pockets.   
four prototypes of environmental sensor modules, including external temperature detector and two chemical detectors, were first calibrated and then delivered for usability evaluation that was carried out within field trials (wp7).   
the next modules of i-protect ppe system were developed within wp4: new materials based on nanotechnology. the main objectives of wp4 was to develop new functionalized carbon nanotubes suitable for application in fabrics in order to elaborate 1) conductive paths and 2) to develop new chemiresistive layers for indication the presence of toxic gases and to develop textile fabrics with anti-electrostatic properties. studies on preparation and functionalization of carbon nanotubes (cnt) in stable suspensions were carried out. conductive nanomaterials based on multi-walled carbon nanotubes (mwcnt) were developed and applied on textile substrates.   
relevant studies and characterization of the electrical responses of the different series of the developed paths were performed. the results showed that generally the conductivity of the paths is reliable i.e. electricity is passing through the paths at high quality.   
experiments on the preparation of functionalized carbon nanotubes stable suspensions for the development of chemoresistive active layers were undertaken. investigation on the appropriate conductive binder suitable to elaborate the nanostructured gas sensor was also carried out. electrical characteristics for the developed nanostructured gas sensors were measured together with determination of responses to defined inorganic gases.   
experiments on the preparation of nanometals potentially responsible for anti-electrostatic properties were performed. the anti-electrostatic properties of textiles decorated with nanometals were measured. prototypes of antielectrostatic fabrics were developed.   
a crucial element of the i-protect ppe system was the communication system network which was developed within wp5: communication. the aim of wp5 was to ensure reliable communication between all sensory modules as well as in order to control, use and maintain the data collected by the sensors relevant communication sub-modules and units were developed. the heart of the communication module is the unit of pda responsible for wireless transfer of data between end-users and the rescue coordination centre (rcc). the specific communication unit module (so-called pda â personal digital assistant) was developed and successfully integrated with standard mobile radio commonly used by the rescuers.   
the wireless communication between the sensor modules and the communication module relied on elaborated and adjusted body are network module (ban).   
the communication between the end-user and the rcc was achieved by adaptation and relevant adjustments and reprogramming for the project purpose selected elements of mototrbo communication system offered by motorola.   
the main function of the rcc, apart from ensuring proper data transmission from sensors, was to maintain voice communication between the rcc operator and the end-users and to record, store and display crucial information related to the current health status of each rescuer i.e. heart rate and thermal load based on physical strain index as well as all other information transmitted from sensory modules i.e. the concentration levels of gases, the value of external temperature and the content of breathable air in pressure vessels of breathing apparatus.   
the final part of the technical development phase of the project was carried out within wp6: integration, testing and adjustment. the main objective of wp6 was to ensure the proper integration of all technologies, materials and modules developed within work packages wp2, wp3 and wp5 into one homogenous ppe system.   
the integration level of the system was evaluated during laboratory tests where all materials used for protective equipment integrated with sensors and electronic modules were tested for their protective and mechanical properties (protective clothing for fire-fighters and mine-rescuers, suits for chemical rescuers), proper functioning of physiological and environmental sensors, proper operating of communication unit module (when connected with the rescue coordination centre), protective properties as well as comfort of use of the whole ppe system (practical performance tests, thermal comfort). tests for interconnections of every component and module were carried out. evaluation based on electronic measurement method i.e. analysing the strength and the spectrum of the electronic signals was applied for the assessment of functionality of physiological sensors integrated with textiles and monitoring unit, environmental sensors, communication unit and all other communication elements of the communication system including the rescue coordination centre.   
based on the achieved results the recommendations for further system improvements were prepared. samples of textile materials used for manufacturing of protective clothing for fire-fighters, mining and chemical rescuers were tested in laboratory in accordance with the requirements of relevant ppe en standards. full assessment of protective and mechanical parameters i.e.: permeation of chemicals through protective clothing after embedding environmental sensor, flame resistance and thermal properties for textiles for protective clothing for fire-fighter garments, anti-electrostatic properties of materials for mine rescuers and total inward leakage for chemical protective clothing were performed. assessment of functionality and usability parameters included practical performance test with human test subjects.   
as a result of the integration activities six prototypes of the ppe system in three versions were developed i.e. two for fire-fighters, two for mine rescuers and two for chemical rescuers. all of these prototypes were integrated with sensory modules and communication system elements. draft work manuals for end-users of each version of the ppe system were also prepared.  
phase 3 - verification and validation  
all six prototypes of the ppe system were confronted with real conditions within wp7: verification and validation which constituted the 3rd phase of the project. verification and validation whether the prototypes of ppe system complies with the specifications and requirements defined on the basis of the target end-users needs and demands within wp1 were carried out by means of field trials. the field trials were performed by professional end-users in specific training chambers and in simulated rescue activities on chemical installations, in the mines and in fire-fighting dedicated constructions respectively.   
during the trials the functionality, safety, usability as well as comfort of use (ergonomics) of all three versions of the ppe systems were evaluated by test subjects. prior to that relevant questionnaires for the ppe system assessment were elaborated. based on the obtained results adequate recommendations for further improvement of the ppe system including underwear with physiological sensor module, protective clothing with environmental sensor modules as well as reliability of communication between components of the communication system and between end-user and the rcc were elaborated and discussed with the partners.   
recommendations for the improvement of application for data visualization in the rcc as well as usability of the rcc were also defined. results of system verification and recommendations for the improvement as well as conclusions derived from the integration and adjustment activities performed within wp6 were taken into consideration when developing the principles of manufacturing concept of the complex ppe system of another result of the project.  
phase 4 â dissemination and exploitation  
in parallel to all research activities of the project relevant dissemination and standardization activities were carried out within wp8: pre-standardization and dissemination of project results. the main objective of wp8 was to formulate strategy for standardization and legislation concerning aspects of the newly developed ppe system and to formulate guidelines for developing pre-normative documents for that system. dissemination and promotion of the project results were also performed within this work package. activities corresponding to formulation of the strategy for standardization included initiation and maintenance of contacts with relevant cen and iso technical committees in order to provide its members with information about the normative aspects of intelligent personal protection system being developed within the project. representatives of the project partners participated in various meetings of cen technical committees, ppe sector forum workshop and working group cen-clc bt wg 8 - protective textiles and personal protective clothing and equipment. based on the gathered information concerning the plans for future standardization in the area of smart protective textiles, personal protective clothing and equipment, as well as taking into account the analysis of the current international legislation (standards, ppe directive), the results of ongoing and completed fp7 projects, recent technological progress in the area of functional textiles and their integration with electronic elements, sensors and ict solutions all crucial demands related to the improvement of the existing standards or needs for new standards were recognized.   
the results of i-protect project were widely disseminated at various events including sic international and national conferences, two seminars, one workshop and three trade fairs. the outcomes presented at these events included all sensory modules, communication modules and the whole ppe system. the results of i-protect project were also disseminated at the press conference in spain. the materials from the press conference were presented in newspapers, radio and tv (articles and emissions). a leaflet containing the information about the project has also been developed and distributed at each of the mentioned dissemination events.   
  
project results:  
introduction  
  
firefighting, chemical rescue as well as mine rescue activities belong to the most physically demanding professions, requiring personnel to carry out a number of high-intensity tasks. all tasks associated with rescue activities are performed in atmospheres with hazardous contaminants which may affect respiratory tracks and/or other parts of the human body. the rescuers are faced with sudden situations where hazards such as direct exposure to flame, high temperature, unknown concentration of various gases, poor, limited or lack of visibility may occur. another important factor that may negatively influence the working conditions of rescuers is the lack of communication between the rescue team members or between a rescuer and a command centre. firefighting as well as chemical and mine rescue demand significant physical efforts when rescuers are engaged in activities such as carrying a victim rescue from e.g. multi-storey buildings, transportation of equipment of different type and size, pulling a trailer, ladder and stair climbing, opening a stiff valve, carrying fire hose, running out hose reels etc. therefore assuring a high-level protection of the rescuers by the use of appropriate personal protective equipment (ppe) solutions is a fundamental prerequisite for improving the rescuers safety, health and saving their lives.  
  
ppes currently available on the market and being used by fire-fighters, chemical rescuers and mine rescuers are usually composed of separate, passive elements and modules without proper interconnections and interactions. sometimes those elements are even not compatible with each other since they are designed to protect the user separately against one defined type of hazard or risk.   
the ppes commonly used by the rescue team members typically include: protective clothing (garments, gas tight suits to be used against chemicals); hand and foot protection (gloves, footwear), and respiratory protective equipment (self-contained breathing apparatus with full face mask as well as separate full face or half mask usually equipped with combined gas filters).   
in order to improve safety and health protection of personnel operating in such high risk and complex environments there is a need for modification, improvement and enrichment of the existing ppe solutions by introducing novel technologies and innovative concepts i.e. monitoring of physiological parameters of the user, controlling environmental hazards existing in external atmosphere and monitoring of protective parameters of ppe elements. the crucial issue is also to ensure high level of comfort of these complex and modular ppe solutions. functionality of currently used ppes can be significantly increased through careful selection and integration of so-called âintelligentâ or smart functional materials (including those based on nanomaterials), sensory modules, wireless communication systems, optical fibers, flexible antennas, new small and flexible power sources etc.   
therefore, the main scientific and technological aspects of i-protect project concerned the concept idea of integration, within the newly created ppe system, of state-of-the-art materials, optical fibre sensors, gas and temperature detectors, advanced wireless communication technologies as well as the development and use of new, nanotechnology-based materials in order to enhance protection level and multi-functionality of ppe system. the project also focused on ensuring that the newly designed ppe system conforms to ergonomic requirements and is evaluated and validated by the users in terms of its safety, comfort of use and performance level during practical performance tests in conditions simulating real rescue activities.   
the course of i-protect project activities was organized in the following 8 interrelated work packages:  
  
wp1: identification of end-users needs and defining technical, usability and protective requirements for the ppe system and its separate elements  
wp2: development of sensors for monitoring physiological parameters of the end-users  
wp3: development of environmental sensor modules for monitoring concentration levels of toxic gases and external temperature  
wp4: development of new materials with special properties based on nanotechnologies  
wp5: development of efficient communication system ensuring data transfer between developed sensory modules and the rescue coordination centre  
wp6: integration of all developed modules of the new ppe system in order to meet the specifications and the requirements defined by end-users  
wp7: validation that newly developed ppe system is safe and complies with ergonomic and usability requirements as well as ensure appropriate comfort of use  
wp8: pre-standardization and dissemination activities including among others determination of gaps in existing en standards in relation to the requirements and assessment methods for novel innovative ppe systems   
  
the main scientific and technological results (foreground)  
all initial activities to the main technical development works were carried out within work package wp1. the main objective of wp1, lead by ciop-pib, was to specify protective and usability requirements for developing an innovative ppe system on the basis of analysis of work-related hazards and end-users needs in three target sectors: fire fighting, chemical rescue and mining rescue. the requirements were defined in close collaboration and involvement of representatives of end-users i.e. vfdb, komag, csrg, and pkn orlen. moreover, involvement of other project partners responsible for the core development of each single module i.e. bam, colorobbia, honeywell, aerosekur, neovision, coalesenses and tecnalia, helped to collect and analyse the information which was subsequently taken into consideration during technical development activities of the project.   
the deliverable produced within wp1 was the report on âidentification of hazards and risks in specified rescue activitiesâ (d1.1.). the report includes the analysis of various scenarios that may occur during hazardous incidents at chemical and petroleum plants as well as fire-fighting and mining rescue operations. the analysis was focused on the recognition of crucial safety factors playing a key role in rescue operations. in the case of chemical rescue activities and fire-fighting, the contamination of toxic substances, high temperature leading to heat stress, limitation in the field of vision and access to breathable air, were highlighted as the most important. additionally, for fire-fighting direct exposure to flame, fume and water as well as operations in confined spaces with limited visibility were considered as the most dangerous factors. for mining rescue operations, which are frequently carried out in potentially explosive atmosphere, the need for use of the protective clothing with anti-electrostatic properties as well as the need for sensors detecting the concentration of explosive and harmful gases were underlined.  
the analysis was carried out in close cooperation with end-users represented by three project partners, i.e. pkn orlen (large petrochemical company) â partner responsible for the area of chemical rescue activities, csrg (central mining rescue station) â partner responsible for the area of mining rescue activities and vfdb (german fire protection assosiation) â partner responsible for fire fighting. the analysis was carried out by investigations of operational reports from real rescue actions. additionally tecnalia (spanish research and development company) was responsible for risk analysis in the field of fire-fighting and komag (institute of mining technology) dealth with risk analysis in the mining rescue operations.  
the final report (d1.1) on identified hazards and risks in specified rescue activities was used as an input for the next task which focused on the preparation of technical requirements and specification for ppe modules and for the whole system.   
the second deliverable generated within wp1 was the report on âspecification of end-users needsâ (d1.2). the report was also prepared on the basis of the information collected from the end-users representing fire fighters, mining rescuers and chemical rescuers. data collected during interviews with the end-users in poland, germany, france and spain, was obtained by means of relevant questionnaires on safety aspects of ppe being in use, their comfort and functionality. the report also took account of ideas for improvement and other requirements or needs expressed by the end-users. then, the information included in this report was used as an input for the preparation of technical requirements and specification for all modules of the ppe system.   
the third deliverable of the wp1 was the report on âtechnical requirements with integration guidelines for ppeâ (d1.3), which contains concrete specifications for developing ppe system prototypes. the technical specification as well as overall concept of the ppe system design were carefully taken into account in technical developments that were to be carried out within wp2, wp3, wp4, wp5 and in integration activities planned within wp6. the study for optimization of ppe system design was carried out in order to verify their modularity, interconnections and interactions (integration) of all ppe system components. the study on possible solutions for integration of physiological and environmental sensors with textiles and/or with other materials as well as with ready-to-use ppe components was carried out by partners responsible for the development of sensory modules i.e. by bam, neovision, ciop-pib, aerosekur and colorobbia.   
some technical requirements for individual modules and the whole system were defined within the wp1 at a certain level of details. for example the exact detection range of environmental sensor modules for toxic gases, accuracy of gas detectors, size and location of the environmental sensor modules, way of integration of optical fibres with textile material etc. could not be specified in details at that stage of the project. all these requirements were subject of further verification and were finally specified in the course of each of technical work packages i.e. within wp2, wp3, wp4 and wp5.  
the main scientific and technological results of i-protect project were obtained within the following work packages: wp2: sensors for monitoring physiological parameters, wp3: sensors for monitoring environmental parameters, wp4: new materials based on nanotechnology, wp5:communication.   
the objective of wp2, which was led by bam with support of safibra, fioh, aerosekur and orneule, was to develop and integrate sensors for monitoring health status of rescuers, namely heart rate, breathing rate and body temperature. the first step within wp2 was to define specification of the sensors and the sensor unique design which both constituted the contents of deliverable d2.1. several possible fibre optic sensing techniques for monitoring of respiratory rate, heart rate and body temperature were investigated:  
  
â¢ sensors based on optical time-domain reflectometry (otdr),  
â¢ sensors based on long period gratings (lpg) in microstructured polymer optical fibres (mpof),  
â¢ sensors based on intensity measurements, and  
â¢ sensors based on fibre bragg gratings (fbg).  
  
furthermore first proof-of-concept prototypes of monitoring units were tested and first trials of integrating optical fibres into textiles were made. the results were used to develop the design of the sensors concept.  
relevant solutions based on selected optical fibres (deliverable d2.2) i.e. lpg mpof (sensors based on long period gratings in microstructured polymer optical fibres), pof otdr (sensors based on optical time-domain reflectometry) and silica fbg (sensors based on fibre bragg gratings) for the measurement of the respiratory rate and the body temperature had been developed first.   
prototypes of physiological sensors (deliverable d2.3) were fully characterized for their sensitivity and limits in use within the laboratory tests carried out on a specially designed test facilities. static and dynamic tests of intensity based sensors and fbg sensors were performed. test of silica fbg sensor for measurement of skin temperature was carried out. functionality tests of combined heart rate and respiratory sensor on different body locations were also performed.  
in parallel the prototype of the small portable and robust monitoring unit (deliverable d2.4), which included hardware and software to control the physiological sensor module, was developed by safibra. the unit was designed so that it can be used for three different types of sensors: for macrobending sensor, for fbg sensor and for mpf lpg sensor. the unit with fbg and lpg sensor and a wavelength to intensity converter was integrated with the unit. six samples of monitoring unit were prepared and sent to wp2, wp5 and wp6 partners in order to allow their performers to define of localization of the unit on the underwear, make it possible to perform tests to evaluate the performance of the unit integrated with underwear and physiological sensors as well as to carry out integration tests to evaluate data transmission between the monitoring unit and the other parts of the ppe system.  
the selected optical fibres were integrated with the textile material of the underwear by means of special elastic â flexible belt, which constituted the deliverable d2.5. then, the belt was embedded into the newly designed underwear (deliverable d2.6) at a chest level in order to pick up to physiological signals. the locations of the elastic belt were consulted with the end-users. the prototypes of underwear were made of stretchable textile in order to fit to the rescuesâ body and were supplied by orneule oy and aero sekur. as a result the design of underwear with the physiological sensors makes is possible to easily connect and disconnect health status sensors to the monit ...

# IMPTEST

Project Acronym: IMPTEST

programme & topic: FP7-JTI JTI-CS-2010-4-SFWA-02-011

Most frequent returning words in objectives:

* ('shields', 33)
* ('impact', 31)
* ('project', 18)
* ('velocity', 17)
* ('weight', 14)
* ('fibres', 13)
* ('performance', 12)
* ('aircraft', 11)
* ('metal', 11)
* ('penetration', 11)
* ('influence', 11)
* ('temperature', 11)
* ('concepts', 10)
* ('shield', 8)
* ('polymer', 8)
* ('temperatures', 8)
* ('protection', 7)
* ('phase', 7)
* ('results', 7)
* ('design', 6)
* ('fibre', 6)
* ('oblique', 5)
* ('times', 5)
* ('future', 5)

executive summary:  
imptest has involved gas gun impact testing of shields made of composite materials for protection of aircraft against small metal fragments generated by failure of rotating engine components. three different sizes of steel cylinders were used to represent engine fragments in different applications. the test campaign included three phases, where phase 1 involved impact perpendicular to the panels to find the ballistic limit velocity for penetration of metallic shields and three different composite shield concepts, using three different impactors at velocities below 600 m/s. phase 2 involved studies of the influence of impact angle for the two selected design concepts, while phase 3 studied the influence of material aging for the selected shield concepts. furthermore, fibre bundles were tested at -40â°c, +23â°c and +80â°c or +120â°c, and the results were used in impact simulations to study the influence of temperature. high speed photography was used to record the impact response history of all specimens. the damage in all specimens was characterised quantitatively and qualitatively using various fractographic methods and by 3d scanning of the deformed shape after impact.  
  
the work in imptest is closely linked to the project impshield, where the impact shields were designed and manufactured. both projects involved participation from imperial college and swerea sicomp. evaluation of the tests in phase 1 revealed that the two design concepts with polymer fibres were clearly superior, and these were selected for oblique impact testing in phase 2. the penetration velocity per unit weight of the selected composite shields was 2-3 times higher than for corresponding metal shields. the oblique impacts in phase 2 demonstrated that the penetration velocity is fairly proportional to the impact velocity component perpendicular to the impact shield. hence, small impact angles require extremely high velocities for penetration. furthermore, non-penetrating oblique impacts on laminated composite shields result in a peculiar response, where the projectile is trapped inside the laminate and slides between the plies until it is fully arrested. panels which had been aged in hot/wet conditions were tested in phase 3, but the difference in impact performance was insignificant. tensile tests demonstrated that temperature changes between -40â°c and +23â°c only had a moderate influence on fibre strength, but that the strength dropped significantly at temperatures around +100â°c. the stiffness measurements can be used for future more detailed simulations of the influence of temperature.  
  
the project has demonstrated that ballistic shields made from polymer fibre composites provide efficient lightweight protection of aircraft against engine debris and that their performance per unit weight is 2-3 times better than for corresponding metal shields. such shields will facilitate the use of open rotor engines mounted on the rear aircraft fuselage, and the reduced weight will contribute to reductions in fuel consumption and harmful emissions. aging in hot/wet conditions appears to be a minor problem, but use at higher temperatures must be carefully considered, as the mechanical properties of polymer fibres change at higher temperatures. the most efficient composite shields experience significant deflections during impact, which requires consideration during design. furthermore, the tests highlight the need to consider the attachment of the shields to the substructure to avoid local failure, e.g. at bolt holes.  
  
project context and objectives:  
reduced weight and more efficient engines of future aircraft are vital to satisfy european and international goals for reducing the emissions and climate impact of aviation. the structural weight is primarily reduced by increased use of polymer composites, which combine superior mechanical performance with low weight. open rotor jet engines with an uncontained fan section and are considered as a promising concept for reduced fuel consumption. for several reasons designers prefer to mount such engines directly on the rear part of the fuselage.  
  
failure of rotating aircraft engine components may result in fragments thrown outwards at high velocity, and such fragments may easily damage the fuselage or other primary structure of the aircraft. the risk is particularly serious for uncontained engines mounted close to the fuselage, as envisioned for future open rotor concepts. thus, a reliable and lightweight shielding is crucial for the fuselage sections exposed to such high velocity impact.  
  
the objective of the accompanying project impshield is design and manufacture of three alternative design concepts for protective shields of composite material, capable of preventing penetration for a range of impactor sizes and velocities relevant for the aircraft manufacturers involved in the project. the objectives of the project imptest is to compare the impact performance of the composite shields manufactured in impshield with conventional metal shields exposed to projectiles with a velocity of several hundred m/s. more specifically the following issues were studied:  
  
â¢ determination of the penetration threshold velocity (v50) for each shield and projectile size  
â¢ ranking of the composite shields and metal shields considering performance versus weight  
â¢ quantification of residual deflections after impact and maximum deflections during impact  
â¢ inspection and description of the resulting damage after impact  
â¢ influence of impact angle on penetration velocity and damage  
â¢ influence on the impact performance after aging in hot/wet conditions  
â¢ measurement of fibre properties at reduced and elevated temperatures to allow simulations of impacts beyond the room temperature test conditions.  
  
project results:  
the main results include quantification of the penetration velocity for the three composite shield concepts and some reference metal shields exposed to projectiles of different size and velocity.  
the projectiles included three sizes (small, medium and large) representative for the aircraft of the associated manufacturers.  
  
the main result was that the composite shields with polymer fibres had a penetration threshold velocity per unit weight which was 2-3 times higher than conventional metal shields, while composite shields with glass fibres had a performance similar to the metal shields. the best performance was found for shields with ultra high molecular weight polyethylene fibres, while the performance of shields with aramid fibres was somewhat lower.  
  
comparison of the results for various impact angles revealed that penetration is more or less directly related to the velocity component perpendicular to the shield. thus, oblique impact requires significantly higher impact velocities for penetration. during oblique impact projectiles in composite shields were deflected and then slipped between two interior plies while projectiles in metal shields followed a path which was an extension of the direction before impact.  
  
the polymer shields were manufactured by hot pressing layers of aramid textile weave with a binder powder or pre-impregnated layers of uhmw polyethylene fibres. fibre bundles extracted from the weave or pre-impregnated layers were tested in tension at different temperatures. the strengths at â40â°c and +23â°c did not differ significantly. increasing the temperature to 120â°c caused a moderate strength reduction for the aramid fibres while a severe reduction was observed already at +80â°c for the uhmw polyethylene fibres. the influence of temperature on stiffness and elongation at failure were also measured.  
  
the data on temperature influence on fibre properties may be used in simulations of impact at temperatures deviating from the room temperature used in gas gun tests.  
  
potential impact:  
the project has quantified the ballistic performance of three composite shield concepts and compared them with conventional metal shields. the two shields with polymer fibres provided 2-3 times higher perforation threshold velocity per unit weight, i.e. 2-3 times lower weight for protection at a given velocity.  
  
the service temperature should be considered in the choice of material as shields with ultra high molecular weight polyethylene fibres perform better at low and moderate temperatures, but are unsuitable at temperatures approaching +80â°c, while aramid fibres show an acceptable performance up to +120â°c.  
  
the studies of the influence of impact angle, temperature and material aging for a range of different projectile sizes provides increased confidence in the use of composite shields as an alternative to metal shields for ballistic protection. the introduction of composite shields for ballistic protection of aircraft is likely to cause significant weight savings in future aircraft where such protection is required. these weight savings are directly transferred into reduced fuel consumption and less harmful emissions affecting the climate and human health.  
  
all the results of the project have been disseminated to the industrial partners linked to the project, i.e. dassault aviations, airbus innovation and airbus in france and spain. due to time constraints, and the fact that most experimental results were obtained during the final year of the project no results have yet been published in scientific journals or conferences.  
  
the following articles in peer reviewed journals are planned after completion of the project:  
1. one article presenting a comparison of the performance of the different shield concepts  
2. one overview article on the project aims and different issues studied in the project  
3. one article presenting the influence of temperature on the properties of polymer fibres  
  
the exploitation of the concepts for design of composite shields for ballistic protection will be further considered in feasibility studies for future aircraft performed by the industrial partners of the project.  
  
the knowledge and experience gained in modelling and testing of high velocity impact on composite materials will be used by swerea sicomp and imperial college to strengthen their further research in this area. this will benefit the general european research community in high velocity impact via the joint network of both organisations.  
  
list of websites:  
no public project website is available. further information can be obtained from the project partners:  
dr robin olsson (project coordinator), swerea sicomp (www.swerea.se/en/sicomp)  
prof. lorenzo iannucci, dept of aeronautics, imperial college (www.imperial.ac.uk/engineering/departments/aeronautics)

# FRONT

Project Acronym: FRONT

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('project', 16)
* ('textile', 13)
* ('fabrics', 13)
* ('flame', 11)
* ('retardant', 10)
* ('products', 9)
* ('front', 8)
* ('properties', 8)
* ('order', 6)
* ('market', 6)
* ('results', 6)
* ('nanoparticles', 6)
* ('fibers', 5)
* ('time', 4)
* ('quality', 4)
* ('cotton', 4)
* ('health', 4)
* ('polyester', 4)
* ('combustion', 4)
* ('toxic', 4)
* ('substrates', 4)
* ('neat', 4)
* ('research', 4)
* ('approach', 4)

executive summary:  
the main objective of front project, taking advantage of nanotechnologies, was to obtain textile fabrics with flame retardant properties in order to have optimal properties durable in time and to be used in different field of applications (protective garments, furniture upholstery bed linen).  
front purpose was to introduce finishing products, based on nps, in european textile market, to produce textile fabrics resistant to fire with high performance and quality, as requested from evolution of legislation and from customer attention.  
  
project context and objectives:  
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front purpose was to introduce finishing products, based on nps, in european textile market, to produce textile fabrics resistant to fire with high performance and quality, as requested from evolution of legislation and from customer attention.  
current market solutions for flame retardant (fr) effect present several criticalities:  
- cotton (cot): the use of chemical products in finishing (the only technical possibility at the moment) is not completely compatible with international standards on health and safety;   
- man made fibers (particularly polyester, pet): current processes consent to create fr fibers used for specific aims (i.e. firefighters bunker gears, workers uniform, racing uniform etc). the intrinsically fr fibers have a high cost; fibers present rigidity, a huge problem for storage and, above all, for use in clothing manufacture. moreover, during combustion pet creates burning drops.  
- blended fibers: usually they present a flammability that is worse than that of either component alone.  
- toxic smokes: current anti-flame treatment do not face properly the release of a high quantity of toxic smokes during combustion and the environmental impact of products themselves.  
  
project results:  
textile fabrics of interest for companies involved in the project have been selected and characterized in the first phase of project activities. each industrial partner (ind) selected textile substrates specific for its own market sector, to be characterized. substrates were divided into two main groups:  
\* reference flame retardant fabrics. they represented the state of the art for flame retardant properties produced by the ind partners and served to set-up the objective of the project.  
\* reference fabrics for trials. they were not flame retardant fabrics but standard fabrics ready to receive the nanoparticles (nps), in order to evaluate the effects of the innovative treatments.  
textile substrates were planned as different blends, without the exclusion of neat substrates, of polyester and cotton, considering their diffusion and the substantially low cost.  
during project activities implementation, research and tests were focused on neat polyester and blend fabrics as for neat cotton fabrics first results were not encouraging. in any case, cotton fabrics first test results are part of project report as they give know-how and knowledge useful for understanding the issue.  
  
research activity focused then on the identification and selection of nps able to give flame retardant properties to textile fabrics during finishing step. different aspects were taken in consideration, such as, for example, size and shape, non-toxicity, non-halogenated content, solubility in aqueous media, potential flame retardant properties. another important theme considered has been the availability on the market, as it was essential to find out results with nps easy to find and with a cost affordable for a future market exploitation.  
a detailed selection of nps has been carried out by politecnico di torino research group involved, on the basis of experience developed through the participation to research projects about the use of nanoparticles as flame retardant additives in polymer matrices via melt blending.  
selected nanoparticles have been characterized (morphological, structural, chemical and thermal point of view) and a lab-scale approach was optimized in order to mimic the finishing industrial treatment and furthermore to obtain prototypes to test in terms of combustion behavior. finally, optimal conditions to obtain the highest adhesion of nanoparticles on the textiles have been defined.  
activities performed leaded to find out a series of 5 nps resulting the most promising fillers as flame retardant additives for polyester matrix. through cone calorimetry measurement it has been demonstrated that the presence of these nanofillers change the combustion behavior of the neat textile. important parameters such as time to ignition (tti), peak of heat release rate (pkhrr), total smoke release (tsr) and optical density of smokes (sea) are modified.  
the great advantage of this approach is the addition of low amounts of nanoparticle used in comparison with the traditional/commercial flame retardants, that was one of main project objectives.  
one of the 5 nps selected has been submitted to an industrial approach with the collaboration between politecnico di torino and europizzi s.p.a. introducing commercial elements in order to ameliorate the nanoparticle dispersion and stability.   
moreover, in order to improve the durability properties in the time, the use of commercial crosslinkers was applied. one of possible risks pointed out in project preparation phase was the scarce adhesion of nanoparticles on the textiles. for this reason, two different approaches has been tested only on laboratory scale: a first one based on a pretreatment of the surface textile by etching (plasma technology) and a second one, based on the formation of a coating (sol-gel process). the two approaches haven't been prosecuted in subsequent trials, concentrating on other approaches and technologies selected in the project.  
  
potential impact:  
as concerning benefits for citizens, results provided by front will reduce the risk of fires increasing overall health conditions and quality of life in the eu.  
  
the aim of front was also to look for new technologies and/or approaches to improve eu citizens health and quality of life and to reduce the use of toxic substances and effluent emission and to comply to the directive on integrated pollution prevention and control (ippc) and reach) directed to encourage a sound environmental approach to industrial waste problems.   
the contribution of the project to preserving and/or enhancing the environment and natural resources will be mainly due to the reduced quantity of chemical products which will have to be used in the finishing treatment, and the emission of toxic waste in the effluent water again contributing indirectly to citizen's health.  
the avoidance of use of noxious chemicals will substantially improve working conditions.  
front will play a role in contributing to sustainable development through reduction of material content of products whilst increasing their service value, and through innovative, safer, cleaner and low resource intensity processes. also new methods of organising production will, through the project, reduce costs.   
  
resources invested during front project were not sufficient to solve all the problems concerning fr products and the technological transfer from plastics sector to textile sector concerning the use and the behaviour of nanoparticles. it is possible, anyway, to underline the results gained thanks to the efforts of partners involved in the projects. as an example, the compounding recipes used by europizzi could be improved and could be basis of new formulates and products. as a second example, industrial partners could define new definitive industrial processes to be applied to create new products  
  
list of websites:  
europizzi s.p.a. carlo pilenga, carlo.pilenga@europizzi.it   
  
antecuir s.a. rafa agullã², r.agullo@antecuir.com   
  
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politecnico di torino jenny alongi, jenny.alongi@polito.it   
  
klopman international s.r.l. antonio andretta, antonio\_andretta@klopman.com   
  
project website www.projectfront.eu

# FRONT

Project Acronym: FRONT

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('project', 16)
* ('textile', 13)
* ('fabrics', 13)
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current market solutions for flame retardant (fr) effect present several criticalities:  
- cotton (cot): the use of chemical products in finishing (the only technical possibility at the moment) is not completely compatible with international standards on health and safety;   
- man made fibers (particularly polyester, pet): current processes consent to create fr fibers used for specific aims (i.e. firefighters bunker gears, workers uniform, racing uniform etc). the intrinsically fr fibers have a high cost; fibers present rigidity, a huge problem for storage and, above all, for use in clothing manufacture. moreover, during combustion pet creates burning drops.  
- blended fibers: usually they present a flammability that is worse than that of either component alone.  
- toxic smokes: current anti-flame treatment do not face properly the release of a high quantity of toxic smokes during combustion and the environmental impact of products themselves.  
  
project results:  
textile fabrics of interest for companies involved in the project have been selected and characterized in the first phase of project activities. each industrial partner (ind) selected textile substrates specific for its own market sector, to be characterized. substrates were divided into two main groups:  
\* reference flame retardant fabrics. they represented the state of the art for flame retardant properties produced by the ind partners and served to set-up the objective of the project.  
\* reference fabrics for trials. they were not flame retardant fabrics but standard fabrics ready to receive the nanoparticles (nps), in order to evaluate the effects of the innovative treatments.  
textile substrates were planned as different blends, without the exclusion of neat substrates, of polyester and cotton, considering their diffusion and the substantially low cost.  
during project activities implementation, research and tests were focused on neat polyester and blend fabrics as for neat cotton fabrics first results were not encouraging. in any case, cotton fabrics first test results are part of project report as they give know-how and knowledge useful for understanding the issue.  
  
research activity focused then on the identification and selection of nps able to give flame retardant properties to textile fabrics during finishing step. different aspects were taken in consideration, such as, for example, size and shape, non-toxicity, non-halogenated content, solubility in aqueous media, potential flame retardant properties. another important theme considered has been the availability on the market, as it was essential to find out results with nps easy to find and with a cost affordable for a future market exploitation.  
a detailed selection of nps has been carried out by politecnico di torino research group involved, on the basis of experience developed through the participation to research projects about the use of nanoparticles as flame retardant additives in polymer matrices via melt blending.  
selected nanoparticles have been characterized (morphological, structural, chemical and thermal point of view) and a lab-scale approach was optimized in order to mimic the finishing industrial treatment and furthermore to obtain prototypes to test in terms of combustion behavior. finally, optimal conditions to obtain the highest adhesion of nanoparticles on the textiles have been defined.  
activities performed leaded to find out a series of 5 nps resulting the most promising fillers as flame retardant additives for polyester matrix. through cone calorimetry measurement it has been demonstrated that the presence of these nanofillers change the combustion behavior of the neat textile. important parameters such as time to ignition (tti), peak of heat release rate (pkhrr), total smoke release (tsr) and optical density of smokes (sea) are modified.  
the great advantage of this approach is the addition of low amounts of nanoparticle used in comparison with the traditional/commercial flame retardants, that was one of main project objectives.  
one of the 5 nps selected has been submitted to an industrial approach with the collaboration between politecnico di torino and europizzi s.p.a. introducing commercial elements in order to ameliorate the nanoparticle dispersion and stability.   
moreover, in order to improve the durability properties in the time, the use of commercial crosslinkers was applied. one of possible risks pointed out in project preparation phase was the scarce adhesion of nanoparticles on the textiles. for this reason, two different approaches has been tested only on laboratory scale: a first one based on a pretreatment of the surface textile by etching (plasma technology) and a second one, based on the formation of a coating (sol-gel process). the two approaches haven't been prosecuted in subsequent trials, concentrating on other approaches and technologies selected in the project.  
  
potential impact:  
as concerning benefits for citizens, results provided by front will reduce the risk of fires increasing overall health conditions and quality of life in the eu.  
  
the aim of front was also to look for new technologies and/or approaches to improve eu citizens health and quality of life and to reduce the use of toxic substances and effluent emission and to comply to the directive on integrated pollution prevention and control (ippc) and reach) directed to encourage a sound environmental approach to industrial waste problems.   
the contribution of the project to preserving and/or enhancing the environment and natural resources will be mainly due to the reduced quantity of chemical products which will have to be used in the finishing treatment, and the emission of toxic waste in the effluent water again contributing indirectly to citizen's health.  
the avoidance of use of noxious chemicals will substantially improve working conditions.  
front will play a role in contributing to sustainable development through reduction of material content of products whilst increasing their service value, and through innovative, safer, cleaner and low resource intensity processes. also new methods of organising production will, through the project, reduce costs.   
  
resources invested during front project were not sufficient to solve all the problems concerning fr products and the technological transfer from plastics sector to textile sector concerning the use and the behaviour of nanoparticles. it is possible, anyway, to underline the results gained thanks to the efforts of partners involved in the projects. as an example, the compounding recipes used by europizzi could be improved and could be basis of new formulates and products. as a second example, industrial partners could define new definitive industrial processes to be applied to create new products  
  
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# SMARTPRO

Project Acronym: SMARTPRO

programme & topic: FP7-SECURITY SEC-2013.1.4-1

Most frequent returning words in objectives:

* ('protective', 41)
* ('fabrics', 30)
* ('body', 29)
* ('fabric', 27)
* ('kevlarâ®', 26)
* ('layers', 25)
* ('stab', 24)
* ('protection', 22)
* ('application', 22)
* ('resistance', 22)
* ('impact', 22)
* ('panel', 19)
* ('textile', 18)
* ('armour', 17)
* ('thermal', 17)
* ('polymer', 17)
* ('panels', 17)
* ('dilatant', 16)
* ('level', 16)
* ('textiles', 15)
* ('surface', 15)
* ('properties', 15)
* ('armours', 14)
* ('weight', 13)

executive summary:  
smartpro aimed to develop optimized protective textiles and apply innovative surface treatments to improve their performance on an areal density basis. thus, fewer fabric layers would be required, resulting in increased flexibility and reduced weight of the armour. main parameters considered also include protection of vulnerable body parts other than the torso, physiological comfort and ergonomic design. additionally, the development and integration of smart systems was envisaged to increase usersâ awareness.   
  
according to the above objectives, a plain weave kevlarâ® fabric was selected as the basic protective textile and alternative surface treatments were applied on it. the treatments explored include: (a) application of shear thickening fluids (stf), (b) application of dilatant powder, (c) coating with ceramic material by thermal spraying, (d) application of nanofibres and sic particles, (e) coating with crosslinkable, side-functionalized aromatic polymer and (f) coating with graphene. resulting treated kevlarâ® fabrics were combined also with untreated layers in various assemblies aiming to develop a panel exhibiting both ballistic (level iiia) and stab (level 1) resistance while weighing up to 5.72 kg/m2 (according to the end-usersâ requirements defined through dedicated workshop and questionnaire survey). while several lightweight panels passed either the ballistic or the stabbing test, combining both protective properties proved challenging, due to the different impact mechanism. at the end, two panel assemblies passed both tests, one weighing 5.76 kg/m2 (very close to the target), and the other 6.00 kg/m2.  
  
in parallel, scale-type composite structures were developed to be used as impact protection systems, required in the case of riot police. the structures consisted of kevlar-reinforced epoxy composite, patterned in hexagonal scales. the scales structure allows for flexibility of the overall structure, while the selected material exhibits high impact strength.  
  
in the frame of the project, a modular carrier for riot police and special unitsâ officers was designed, with the end-users being actively involved in the process. prototype body armours were manufactured accordingly. in parallel, prototype armours for male and female patrol officers were manufactured having the same design as currently used by mossos dâ esquadra (end user participating in the consortium). in this case the outer fabric of the carrier was treated with a photocatalytic polymer endowing self-cleaning and de-polluting properties, while a 3d knitted fabric was used as liner to improve thermal comfort.  
the following smart systems were developed: (a) textile-based heart rate sensor, (b) miniaturized zno nanowire gas sensor and (c) textile antenna. the heart rate sensor was integrated on an undergarment, while the gas sensor and textile antenna were appropriately integrated on a body armour prototype.  
  
lca and preliminary cost analysis indicate that the newly developed armours are competitive in terms of cost to existing solutions, while having reduced environmental impact.  
project context and objectives:  
until recently, the research on body armours for law enforcement personnel concentrated on their ballistic properties. in this context, several new fibres have been developed including kevlarâ®, dyneemaâ®, gold flexâ®, spectraâ®, twaronâ® and zylonâ®. these high-performance yarns are characterized by low density, high strength and high energy absorption. however, to meet the protection requirements for typical ballistic threats, 20-50 layers of fabric are required. this results in bulky and stiff armours that limit the wearersâ mobility and agility and are impractical for use on joints, arms, legs, etc. it is worth noting that the problem of reduced mobility is also very important for custodial and correctional officers who perform their duties in confined areas, such as cells and hallways, where the ability to move and fight off an attacker is very critical. therefore, despite the progress achieved in terms of materialsâ development, the demand for improved flexibility and performance-to-weight ratio of body armours remains high.  
  
moreover, body armour materials have traditionally been designed to protect the wearer against ballistic threats and, thus, they provide only a limited level of protection against knives and sharp blades. this is because the impact force of these objects stays concentrated to a relatively small area, allowing them to puncture even the bullet-resistant fabrics. in fact, the response of a material to stabbing has a completely different mechanism compared to its response to ballistic impact. besides the basically dissimilar structure and size of the objects to be stopped, their kinetic impact energy is fundamentally different. while a bullet with a mass of a few grams impacts the target at a very high velocity, the typical terminal velocity of a knife attack is relatively low with a mass of up to several hundred grams. although stab resistance was not traditionally the main concern when developing personal body armours, recent studies reveal that stabbing has become a main cause of police officersâ injuries. accordingly, there is an obvious need to develop body armours combining ballistic and stab resistance, at the minimum weight and maximum flexibility.  
  
another issue that has not received much attention is the increased physiological strain which is imposed by protective armours due to the added load, increased clothing insulation and vapour resistance. in many cases, law enforcement officers avoid wearing their armour because of the acute discomfort induced by its impermeable components. although loose weave undershirts are commonly used to provide a modest improvement in airflow and sweat evaporation, more effective solutions to ensure physiological comfort are required.   
  
even more, although the main scope of body armour is to provide protection against stab and ballistic threats, unseen hazards, like toxic chemicals, are more challenging to mitigate. for example, typical dangerous chemicals found in clandestine drug laboratories include carbon monoxide, benzene and hydrochloric acid. while commercial chemical detection devices are too cumbersome and expensive to use on a regular basis, innovative solutions need to be sought to allow the incorporation of chemical sensors on textiles.  
  
additional smart functions may further increase the efficiency of the body armour, eventually leading to reduced casualties. in this context, development and integration of heart rate sensors and wearable positioning systems (gps) may increase usersâ awareness.  
  
emphasis also needs to be given on the design of the body armour, as well as on the functionalities of the outer fabric. more specifically, the design should allow adaptation of the protection level to the risk level encountered in distinct situations. therefore, modularity of the body armour is a key demand. in parallel, the design should consider the ergonomic requirements of the end users. concerning the outer fabric of the body armour, its surface functionalization to provide self-cleaning and de-polluting properties may reduce maintenance requirements, which is particularly important considering the limited number of body armours usually available to law enforcement personnel.  
  
finally, innovative solutions are needed for the protection of vulnerable body parts other than the torso. existing protective gear for law enforcement authorities is usually limited to the body armours, including, in some cases, similar systems adjusted around the neck and the groin to protect these vulnerable body parts. solutions that improve the ballistic and stab resistance of textiles on an areal density basis could be adopted for such systems in order to increase their flexibility and allow the wearer to move more freely.   
  
based on the above, the distinct scientific and technical objectives which were set at the smartpro proposal preparation stage are summarized as follows, along with the approaches proposed to address them:   
  
- development of flexible and lightweight ballistic and/or stab resistant textile panels -> (a) optimization of composition and structure of protective textiles, (b) application of alternative surface treatments to increase the ballistic and/or stab protection provided by textiles on an areal density basis (shear thickening fluids, dilatant powders, ceramic coatings, silicon carbide particles, crosslinkable side-functionalized aromatic polymers), (c) assembly of protective textile layers in order to maximize the level of protection while keeping the weight and cost of the panel as low as possible, (d) development of fish-scale type composites as impact protection materials.  
  
- reduced maintenance requirements -> functionalization of the outer fabric of the body armour to induce self-cleaning and de-polluting properties.  
  
- increased awareness -> development and integration of smart solutions, including wearable antenna, heart rate sensor and miniaturized gas sensor.  
  
- comfort and user acceptance -> (a) use of 3d fabric for reduced thermal stress, (b) optimized design considering modularity and ergonomic requirements of the end-users.  
  
- realization and evaluation of prototypes -> manufacture of prototype body armours including protective gear for body parts other than the torso and their evaluation by end-users.  
project results:  
the main scientific and technological results of smartpro are herein presented in four sections. under the section âprotective materials and panelsâ the work conducted to develop lightweight protective panels, which are inserted in the body armour to ensure stab and ballistic resistance, is overviewed. the section âarmour carriersâ describes the design and manufacture of the vests carriers. next section, âsmart systemsâ, summarizes the development of heart rate sensors, gas sensors and textile antennas and their integration on a body armour prototype. finally, the section âlife cycle and cost analysisâ focuses on the assessment of the environmental impact and cost associated with the new body armoursâ development.  
  
protective materials and panels  
the protective panel is the assembly of textile layers which is placed in the body armour carrier and provides the protective properties (ballistic/ stab resistance). the number of fabric layers and the weight of the protective panel is directly related to the level of protection provided. for example, the average weight to area ratio of a panel providing only ballistic protection of level iiia according to the nij standard remains about 6 kg/m2.  
a key objective of smartpro was to develop lightweight protective panels providing both ballistic and stab protection. more specifically, in accordance to the end-usersâ requirements defined early in the project, the target was to develop a panel weighing up to 5.72 kg/m2 and ensuring level iiia ballistic resistance and level 1 stab resistance, according to nij standards 0101.04 and 0115.00, respectively.  
to reach this objective, the consortium followed a bottom-up approach, starting with the selection of basic fabrics, their surface treatment to increase their protective efficiency and the assembly of alternatively treated fabrics in panels, as described below.  
  
selection of protective textiles  
the first step towards the selection and manufacture of the basic protective textiles was the definition of fibres types to be used. recent innovations in materials and manufacturing technologies have led to the discovery of advanced manmade fibres (such as aramid, ultra-high molecular weight polyethylene and others) that provide body armour with extraordinarily improved ballistic protection levels at a significantly reduced weight. following a literature and market survey, the most attractive options in terms of yarns to be used for the basic protective textiles were defined. among those, it was finally decided to use kevlarâ® yarns, considering that some of the proposed surface treatments, e.g. the thermal spraying of ceramic powders, require high thermal stability of the substrate, which is ensured in the case of kevlarâ®, or are expected to apply better on aramid fabrics (e.g. the crosslinkable, side-functionalized aromatic polymers are expected to adhere better on kevlarâ® due to their similar chemical structure).  
the next step was to define the fabric geometry (i.e. type of weave, fibres per yarn, weave density, etc.). this can be a challenging task when aiming at both ballistic and stab resistance, since design parameters for optimizing ballistic defense and stab defense often work against each other. in fact, textiles designed for ballistic protection require sufficient yarn mobility within the weave to avoid premature failures and will not perform well for stab protection. textiles designed for stab resistance require dense weaves to prevent yarns from being pushed aside from the tip of sharp-pointed objects such as knives, needles, awls and ice picks. dense weaves that prevent punctures can lead to premature or punch-through failures in ballistic impacts. usually, ballistic fabrics are densely woven square plain weave or basket weave. it has been observed that loosely woven fabrics and fabrics with unbalanced weaves result in inferior ballistic performance. the packing density of the weave, indexed by the âcover factorâ has an important role in defining the ballistic performance. it is determined by the width and pitch of the warp and weft yarns and gives an indication of the percentage of gross area covered by the fabric. in general, fabrics with cover factors between 0.6 and 0.95 are more effective when used in ballistic applications. when cover factors are higher than 0.95, the yarns are typically damaged during the weaving process and when cover factors fall below 0.6, the fabric may be too loose to be protective.  
in the frame of smartpro, a series of woven kevlarâ® fabrics with varying weights and structures (plain weave, basket weave, warp-rib and a combination of diagonal and reverse face warp rib weave) were manufactured and characterized in terms of mechanical properties and cover factors. according to the characterization results, a plain weave kevlarâ® fabric weighing 200 g/m2 and having a cover factor in the suitable range for ballistic applications was selected as basic protective textile.  
  
surface treatments to increase the protective efficiency  
alternative surface treatments were proposed, developed and applied on the aforementioned basic protective fabric. the aim was to enhance the performance of the fabric, which would allow using fewer layers and, thus, developing a lighter panel. the treatments proposed and studied in smartpro were:  
â¢ application of shear thickening fluids (stfs)  
â¢ application of dilatant polymers  
â¢ application of ceramic coatings  
â¢ application of carbide and graphene-coated carbide particles  
â¢ application of crosslinkable, side-functionalized aromatic polymers  
â¢ application of graphene coatings  
more details on each of the above treatments follow.  
  
application of shear thickening fluids  
shear thickening fluids (stfs) exhibit a yield stress fluid and deformable behaviour under ordinary conditions. however, once a strong impact is applied, they turn solid-like as their viscosity suddenly diverges, showing a non-newtonian flow behaviour. hence, according to studies reported in the literature, stfs can be used as aid materials to improve the performance of regular body armours, allowing the wearer flexibility for a normal range of movement, yet turning rigid and resisting penetration under impact.   
accordingly, the work conducted in smartpro aimed to: (1) develop stfs with optimized composition and characterize them in terms of their rheological behaviour and (2) apply the optimized stfs in protective panels, to increase the protection level on an areal density basis.  
different types of particles were considered for the preparation of stfs, including sterically stabilized pmma model hard sphere particles, raspberry-like particles, fumed silica nanoparticles and non-fumed silica microparticles. based on the rheological characterization of the fluids composed thereof, it was decided to focus on stfs based on non-fumed silica microparticles, since they exhibit effective shear thickening effect, while having an original viscosity (under no shear) that allows their handling.  
two approaches were explored for their application in protective panels. the first involved impregnation of the protective fabric with the fluids by padding. following this approach an improvement of stab resistance was observed; however, none of the panels including stf-treated layers satisfied the requirements set in the project. according to the second approach, the stfs were used to soak 3d knitted kevlarâ® fabric (developed and industrially produced in smartpro), which was subsequently confined in plastic bags. the bags containing the stf-soaked fabric could be used as inserts between kevlarâ® fabrics in the protective panel. however, due to the high weight of the stf-containing bags, this approach was not further tested.   
  
application of dilatant polymers  
application of dilatant polymers on the protective fabric was explored through two alternative routes: (1) coating with dilatant powders obtained from a dilatant foam and (2) coating with a dilatant dispersion obtained from a dilatant gum. the dilatant foam is a stf encapsulated into a foam, while the dilatant gum is a polymer exhibiting high elasticity and specific rheological properties, i.e. almost immediate hardening upon impact.   
â¢ coating with a dilatant foam powder: a dilatant powder was obtained from a dilatant foam using milling equipment. the powder was then applied onto the fabric, pre-impregnated with a binder, by electrostatic deposition. the binder aimed to improve the adhesion of the powder to the textile surface. after spraying with electrostatic powder spray gun, a reticulation process of the resin was applied. however, following this approach it was not possible to achieve homogenous dispersion and adherence of the powder on the textile.  
  
â¢ coating with a dilatant compound: a dispersion of dilatant compound was prepared and applied on protective fabrics by different techniques (padding and coating) and process conditions. the resulting coated fabrics were subjected to impact testing following a modification of en 13277-7:2009 standard. although these tests showed higher impact reduction (referring to the impact force received by the reverse textile surface, in respect with the initial impact force applied to the front surface) for the coated fabrics compared to untreated ones, it was not possible to obtain a lightweight stab and ballistic resistant panel using such coated layers.   
  
application of ceramic coatings  
different thermal spray techniques were implemented as surface treatments on aramid-based protective textiles to enhance their protective properties by applying thin ceramic oxide and metallic layers. thermal spray techniques are easy to apply and relatively low-cost, offering the flexibility of depositing layers of a wide range of materials (even very high melting point ones) on a variety of substrates with complex geometries on large surfaces. it is worth noting that this work is highly innovative as very few research teams are working on textiles protective properties improvement using thermal spraying.   
in the frame of smartpro the potential use of atmospheric plasma spraying (aps) and liquid plasma spraying (lps) in terms of layers deposition on textile surfaces was investigated and thermal spray parameters (plasma power, spraying distance, feed rate etc.) were optimized for each material applied. critical aspects that influenced the design of experiments methodology were the very low surface roughness of the selected textiles and the substrate temperature raise during deposition, since thermal spray is a high temperature technique.  
due to the fact that lps requires suspensions as feedstock materials, stability and homogeneous dispersion of different ceramic oxides (al2o3, tio2, sio2) and binary mixtures (60-80 wt % al2o3 - 20-40 wt % tio2, 60-80 wt % al2o3 - 20-40 wt % tio2) was optimized. however, the lps technique proved unsuitable for successful layers deposition due to the necessity of small spraying distance and consequent textile temperature raise.  
the aps technique was used for the deposition of a metallic bond coat layer prior to ceramic oxide layers to promote adhesion of the coating on the textile. the ceramic oxide (alumina) layer that followed was deposited again using the same thermal spray technique. optimization of the critical aps deposition parameters was also performed for the oxide layer. îïwas shown that after deposition the fabric used as substrate remains unaffected, exhibits uniform deposition of both layers and fabric texture is followed by the coatings system. optimization of thermal spray deposition parameters was performed for each deposited layer on the textile substrate. different optimized set of parameters were selected with the aim to maintain the coating adhesion and simultaneously minimize the weight gain of the textile.  
the treated textiles obtained through the thermal spray deposition of ceramic materials were, in fact, successfully used in combination with untreated and alternatively treated fabrics, for the development of lightweight (ca. 5.7 kg/m2) ballistic resistant protective panels. in the frame of smartpro it was not possible to obtain a panel containing ceramic-coated fabrics and exhibiting both protective properties with that weight, even though further trials and assembly combinations could lead to such result.  
  
application of carbide and graphene-coated carbide particles  
the popularity of silicon carbide (sic) for use in lightweight armour systems is increasing rapidly, mainly due to the significant improvement in cost/performance ratio of sic seen in recent years relatively to established materials like alumina. moreover, despite the fact that sic has a high/similar density (3.21 g/cm3) compared to other ceramics like b4c and al2o3, it offers better resistance for impact pressures above 20 gpa (typical value for large ammunitions and impact at high velocities) .   
for the application of the sic particles the simple technology of pad-dry-curing was investigated here, in order to allow easy scale-up of the process at industrial scale. pad-dry-curing also allows the deposition of a thin coating layer, leading to low weight increase compared to other technologies, such as spray coating. since padding requires the immersion of the textile support into a solution, a specific particle/polymer dispersion had to be prepared. aliphatic polyurethane (pu) resins were selected as the most suitable carriers for the particles. a challenge in ceramic coating application is the homogeneity of the ceramic oxide in the polymer dispersion. ultrasonic (us) treatment was used to avoid agglomeration of solids in the liquids and induce fragmentation phenomena which reduce the particle size, ensuring that a large superficial area is available to interact with impact energy, maximising ballistic and stab resistance effects.  
according to previous results, sic dispersion (sic: 10%wt./v; silcosperse: 10%wt./wt. sic; us treatment @20 khz for 20 minutes) was mixed (ratio 1:1) with a commercial pu resin, sancure 898. since energy absorption is one of the most significant parameters in ballistic/antistab performances, the application of ceramic particles onto kevlarâ® substrates was paired with the deposition of a thin nanofibrous layer before impregnation, considering that nanofibers significantly increase energy absorbing capability during impact.  
in the frame of smartpro, sic-coated kevlarâ® fabrics were successfully used in combination with untreated layers for the assembly of protective panels exhibiting both ballistic and stab resistance while weighing 5.76 kg/m2. it is worth noting that, while a process for the production of graphene-coated sic particles was successfully established, the graphene coating did not appear to further enhance the protective properties and was not further explored in the project.  
  
application of crosslinkable, side-functionalized aromatic polymer  
this work involved the synthesis of aromatic polyethers bearing side cross-linkable double bonds with optimized molecular weights, their coating onto selected kevlarâ® fabrics and subsequent cross-linking. in specific, the target was the development of uniform high polymer loading kevlarâ® fabrics followed by a thermal cross-linking procedure in order to further improve the strength and energy absorbing capability of the polymer-coated kevlarâ® fabrics.   
first, the newly synthesized copolymers were optimized in terms of molecular weight to obtain polymers with excellent film forming properties. pilot scale monomer and polymer synthesis (up to 300g) was also accomplished to meet the needs of the project.   
regarding the coating of kevlarâ® fabrics, in order to accomplish high polymer loadings and uniform coating, different methods (such as immersion into the polymeric solution and pad-dry cure) were applied. although pad-dry-cure resulted in uniform coating, the polymer loading obtained was low. on the other hand, immersion of the kevlarâ® fabrics into polymer solution with high concentration resulted in very high polymer loading, but low quality of the coating. thus, an optimization of the conditions (polymer concentration, the number of times the kevlarâ® fabric is dipped into the polymeric solution, etc) was conducted to produce uniform, high polymer loading on kevlarâ® fabrics with improved mechanical properties. indeed, we succeeded to produce kevlarâ® fabrics with satisfactory polymer loading (12-15 wt%) and uniform coating using a homemade set up.   
the thermal cross-linking process was selected among others (e.g. chemical cross-linking) as an easy way of creating an intermolecular polymer network with improved mechanical properties. the presence of propenyl groups enables thermal cross-linking without the need of any cross-linking agent. optimization of the thermal cross-linking conditions in terms of temperature, time and air conditions took place. thus, the kevlarâ® fabrics were thermally treated under inert atmosphere at 260oc for 30 min up to 1h to be efficiently cross-linked.   
lightweight panels prepared using the optimized thermally cross-linked kevlarâ® fabrics with high polymer loading passed successfully both stab and ballistic resistance tests.  
  
application of graphene coating  
multilayer graphene is an exceptional anisotropic material due to its layered structure composed of two-dimensional carbon. having a breaking strength of 42 n mâ1, where a hypothetical steel film of the same thickness would have a breaking strength of 0.4 n mâ1, graphene is more than 100 times stronger than steel . accordingly, it could be used to enhance the performance of kevlarâ® fabrics.   
within the project, a combination of graphene and polyurethane (pu) was investigated, considering its ability to melt and reseal around the path of the projectile as it impacts the surface and passes through the bulk . graphene nanoplatelets having a thickness of 10-30 nm, plane dimensions 20 to 50 î¼m, carbon content over 97 % and bulk density between 0.02 and 0.1 g/cm3 were used. a coating process was used to apply the nano-dispersion.  
thus, graphene (50 wt %) was added to a pu dispersion and then dried and fixed at 60â°c for 1 h. the amount of graphene/pu resin deposited on the fabric is around 20-25 g/m2, while the presence of graphene was confirmed by sem. crock-meter tests (10 cycles) confirmed that the abrasion resistance is improved since there is no detachment of the coating even if the system is more rigid as confirmed by bending rigidity test (bfast= 1300 âµnm).  
  
assembly of the protective panel  
following the application of alternative surface treatments as described above, resulting textiles had to be selected, combined and assembled in protective panels which would provide level iiia ballistic resistance and level 1 stab resistance, while weighing 5.72 kg/m2 or less (target set in the project). the assembly of the protective panel is itself a challenging task, as various parameters have to be defined, including: the type and number of fabric(s) layers, the assembly sequence (i.e. which fabrics are on the strike face and which are close to the body) and the sewing pattern. a key consideration when aiming at both ballistic and stab resistance is to combine rigid layers (which are generally effective in inhibiting penetration by sharp blades, i.e. stab protection) with more flexible ones which contribute to energy dissipation and, therefore, enhance the ballistic resistance of the panel. accordingly, most of the panels developed in the project consisted of treated and untreated layers, the latter constituting the more flexible section of the armour.   
  
testing of the protective panel  
ballistic tests - ballistic tests were performed according to nij 0104.4 on 40 x 40 cm panels. since the target was to reach level iiia ballistic protection, the tests were performed with a 9-mm caliber fmj (124 g) at a velocity over 435 m/s. according to the standard, a panel passes the test if both following conditions apply: (a) the panel is not perforated and (b) the back-face-signature (trauma) is lower than 40 mm.  
stabbing tests - stab resistance was assessed according to nij 0115.0 under the conditions for protection level 1. accordingly, each panel was first hit with a knife at an energy of 24 j. provided that the penetration of the knife was less than 7 mm, the panel was hit again at an over strike energy of 36 j. at this second strike, the penetration of the knife should be lower than 20 mm.  
  
results  
among the many different types of panels tested, several passed either the ballistic or the stabbing test but failed the other, while only two panels successfully passed both tests. one of them consisted of untreated kevlar layers and layers treated with nanofibers, sic particles and pu and weighed 5.76 kg/m2, while the other consisted of untreated kevlar layers and layers treated with crosslinked polymer and weighed 6.00 kg/m2.   
  
scale composite for impact protection  
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having selected the optimum material and geometry, samples of scales composites were manufactured using kevlarâ® fabrics as reinforcement and epoxy resin as the matrix. the hexagonal pattern was created in the specimens through milling or water jet cutting (depending of the specimen type). finally, the scale composites were glued on a kevlarâ® textile support through contact glue with pressure and activation with temperature.  
  
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# SMARTPRO

Project Acronym: SMARTPRO

programme & topic: FP7-SECURITY SEC-2013.1.4-1

Most frequent returning words in objectives:

* ('protective', 41)
* ('fabrics', 30)
* ('body', 29)
* ('fabric', 27)
* ('kevlarâ®', 26)
* ('layers', 25)
* ('stab', 24)
* ('protection', 22)
* ('application', 22)
* ('resistance', 22)
* ('impact', 22)
* ('panel', 19)
* ('textile', 18)
* ('armour', 17)
* ('thermal', 17)
* ('polymer', 17)
* ('panels', 17)
* ('dilatant', 16)
* ('level', 16)
* ('textiles', 15)
* ('surface', 15)
* ('properties', 15)
* ('armours', 14)
* ('weight', 13)

executive summary:  
smartpro aimed to develop optimized protective textiles and apply innovative surface treatments to improve their performance on an areal density basis. thus, fewer fabric layers would be required, resulting in increased flexibility and reduced weight of the armour. main parameters considered also include protection of vulnerable body parts other than the torso, physiological comfort and ergonomic design. additionally, the development and integration of smart systems was envisaged to increase usersâ awareness.   
  
according to the above objectives, a plain weave kevlarâ® fabric was selected as the basic protective textile and alternative surface treatments were applied on it. the treatments explored include: (a) application of shear thickening fluids (stf), (b) application of dilatant powder, (c) coating with ceramic material by thermal spraying, (d) application of nanofibres and sic particles, (e) coating with crosslinkable, side-functionalized aromatic polymer and (f) coating with graphene. resulting treated kevlarâ® fabrics were combined also with untreated layers in various assemblies aiming to develop a panel exhibiting both ballistic (level iiia) and stab (level 1) resistance while weighing up to 5.72 kg/m2 (according to the end-usersâ requirements defined through dedicated workshop and questionnaire survey). while several lightweight panels passed either the ballistic or the stabbing test, combining both protective properties proved challenging, due to the different impact mechanism. at the end, two panel assemblies passed both tests, one weighing 5.76 kg/m2 (very close to the target), and the other 6.00 kg/m2.  
  
in parallel, scale-type composite structures were developed to be used as impact protection systems, required in the case of riot police. the structures consisted of kevlar-reinforced epoxy composite, patterned in hexagonal scales. the scales structure allows for flexibility of the overall structure, while the selected material exhibits high impact strength.  
  
in the frame of the project, a modular carrier for riot police and special unitsâ officers was designed, with the end-users being actively involved in the process. prototype body armours were manufactured accordingly. in parallel, prototype armours for male and female patrol officers were manufactured having the same design as currently used by mossos dâ esquadra (end user participating in the consortium). in this case the outer fabric of the carrier was treated with a photocatalytic polymer endowing self-cleaning and de-polluting properties, while a 3d knitted fabric was used as liner to improve thermal comfort.  
the following smart systems were developed: (a) textile-based heart rate sensor, (b) miniaturized zno nanowire gas sensor and (c) textile antenna. the heart rate sensor was integrated on an undergarment, while the gas sensor and textile antenna were appropriately integrated on a body armour prototype.  
  
lca and preliminary cost analysis indicate that the newly developed armours are competitive in terms of cost to existing solutions, while having reduced environmental impact.  
project context and objectives:  
until recently, the research on body armours for law enforcement personnel concentrated on their ballistic properties. in this context, several new fibres have been developed including kevlarâ®, dyneemaâ®, gold flexâ®, spectraâ®, twaronâ® and zylonâ®. these high-performance yarns are characterized by low density, high strength and high energy absorption. however, to meet the protection requirements for typical ballistic threats, 20-50 layers of fabric are required. this results in bulky and stiff armours that limit the wearersâ mobility and agility and are impractical for use on joints, arms, legs, etc. it is worth noting that the problem of reduced mobility is also very important for custodial and correctional officers who perform their duties in confined areas, such as cells and hallways, where the ability to move and fight off an attacker is very critical. therefore, despite the progress achieved in terms of materialsâ development, the demand for improved flexibility and performance-to-weight ratio of body armours remains high.  
  
moreover, body armour materials have traditionally been designed to protect the wearer against ballistic threats and, thus, they provide only a limited level of protection against knives and sharp blades. this is because the impact force of these objects stays concentrated to a relatively small area, allowing them to puncture even the bullet-resistant fabrics. in fact, the response of a material to stabbing has a completely different mechanism compared to its response to ballistic impact. besides the basically dissimilar structure and size of the objects to be stopped, their kinetic impact energy is fundamentally different. while a bullet with a mass of a few grams impacts the target at a very high velocity, the typical terminal velocity of a knife attack is relatively low with a mass of up to several hundred grams. although stab resistance was not traditionally the main concern when developing personal body armours, recent studies reveal that stabbing has become a main cause of police officersâ injuries. accordingly, there is an obvious need to develop body armours combining ballistic and stab resistance, at the minimum weight and maximum flexibility.  
  
another issue that has not received much attention is the increased physiological strain which is imposed by protective armours due to the added load, increased clothing insulation and vapour resistance. in many cases, law enforcement officers avoid wearing their armour because of the acute discomfort induced by its impermeable components. although loose weave undershirts are commonly used to provide a modest improvement in airflow and sweat evaporation, more effective solutions to ensure physiological comfort are required.   
  
even more, although the main scope of body armour is to provide protection against stab and ballistic threats, unseen hazards, like toxic chemicals, are more challenging to mitigate. for example, typical dangerous chemicals found in clandestine drug laboratories include carbon monoxide, benzene and hydrochloric acid. while commercial chemical detection devices are too cumbersome and expensive to use on a regular basis, innovative solutions need to be sought to allow the incorporation of chemical sensors on textiles.  
  
additional smart functions may further increase the efficiency of the body armour, eventually leading to reduced casualties. in this context, development and integration of heart rate sensors and wearable positioning systems (gps) may increase usersâ awareness.  
  
emphasis also needs to be given on the design of the body armour, as well as on the functionalities of the outer fabric. more specifically, the design should allow adaptation of the protection level to the risk level encountered in distinct situations. therefore, modularity of the body armour is a key demand. in parallel, the design should consider the ergonomic requirements of the end users. concerning the outer fabric of the body armour, its surface functionalization to provide self-cleaning and de-polluting properties may reduce maintenance requirements, which is particularly important considering the limited number of body armours usually available to law enforcement personnel.  
  
finally, innovative solutions are needed for the protection of vulnerable body parts other than the torso. existing protective gear for law enforcement authorities is usually limited to the body armours, including, in some cases, similar systems adjusted around the neck and the groin to protect these vulnerable body parts. solutions that improve the ballistic and stab resistance of textiles on an areal density basis could be adopted for such systems in order to increase their flexibility and allow the wearer to move more freely.   
  
based on the above, the distinct scientific and technical objectives which were set at the smartpro proposal preparation stage are summarized as follows, along with the approaches proposed to address them:   
  
- development of flexible and lightweight ballistic and/or stab resistant textile panels -> (a) optimization of composition and structure of protective textiles, (b) application of alternative surface treatments to increase the ballistic and/or stab protection provided by textiles on an areal density basis (shear thickening fluids, dilatant powders, ceramic coatings, silicon carbide particles, crosslinkable side-functionalized aromatic polymers), (c) assembly of protective textile layers in order to maximize the level of protection while keeping the weight and cost of the panel as low as possible, (d) development of fish-scale type composites as impact protection materials.  
  
- reduced maintenance requirements -> functionalization of the outer fabric of the body armour to induce self-cleaning and de-polluting properties.  
  
- increased awareness -> development and integration of smart solutions, including wearable antenna, heart rate sensor and miniaturized gas sensor.  
  
- comfort and user acceptance -> (a) use of 3d fabric for reduced thermal stress, (b) optimized design considering modularity and ergonomic requirements of the end-users.  
  
- realization and evaluation of prototypes -> manufacture of prototype body armours including protective gear for body parts other than the torso and their evaluation by end-users.  
project results:  
the main scientific and technological results of smartpro are herein presented in four sections. under the section âprotective materials and panelsâ the work conducted to develop lightweight protective panels, which are inserted in the body armour to ensure stab and ballistic resistance, is overviewed. the section âarmour carriersâ describes the design and manufacture of the vests carriers. next section, âsmart systemsâ, summarizes the development of heart rate sensors, gas sensors and textile antennas and their integration on a body armour prototype. finally, the section âlife cycle and cost analysisâ focuses on the assessment of the environmental impact and cost associated with the new body armoursâ development.  
  
protective materials and panels  
the protective panel is the assembly of textile layers which is placed in the body armour carrier and provides the protective properties (ballistic/ stab resistance). the number of fabric layers and the weight of the protective panel is directly related to the level of protection provided. for example, the average weight to area ratio of a panel providing only ballistic protection of level iiia according to the nij standard remains about 6 kg/m2.  
a key objective of smartpro was to develop lightweight protective panels providing both ballistic and stab protection. more specifically, in accordance to the end-usersâ requirements defined early in the project, the target was to develop a panel weighing up to 5.72 kg/m2 and ensuring level iiia ballistic resistance and level 1 stab resistance, according to nij standards 0101.04 and 0115.00, respectively.  
to reach this objective, the consortium followed a bottom-up approach, starting with the selection of basic fabrics, their surface treatment to increase their protective efficiency and the assembly of alternatively treated fabrics in panels, as described below.  
  
selection of protective textiles  
the first step towards the selection and manufacture of the basic protective textiles was the definition of fibres types to be used. recent innovations in materials and manufacturing technologies have led to the discovery of advanced manmade fibres (such as aramid, ultra-high molecular weight polyethylene and others) that provide body armour with extraordinarily improved ballistic protection levels at a significantly reduced weight. following a literature and market survey, the most attractive options in terms of yarns to be used for the basic protective textiles were defined. among those, it was finally decided to use kevlarâ® yarns, considering that some of the proposed surface treatments, e.g. the thermal spraying of ceramic powders, require high thermal stability of the substrate, which is ensured in the case of kevlarâ®, or are expected to apply better on aramid fabrics (e.g. the crosslinkable, side-functionalized aromatic polymers are expected to adhere better on kevlarâ® due to their similar chemical structure).  
the next step was to define the fabric geometry (i.e. type of weave, fibres per yarn, weave density, etc.). this can be a challenging task when aiming at both ballistic and stab resistance, since design parameters for optimizing ballistic defense and stab defense often work against each other. in fact, textiles designed for ballistic protection require sufficient yarn mobility within the weave to avoid premature failures and will not perform well for stab protection. textiles designed for stab resistance require dense weaves to prevent yarns from being pushed aside from the tip of sharp-pointed objects such as knives, needles, awls and ice picks. dense weaves that prevent punctures can lead to premature or punch-through failures in ballistic impacts. usually, ballistic fabrics are densely woven square plain weave or basket weave. it has been observed that loosely woven fabrics and fabrics with unbalanced weaves result in inferior ballistic performance. the packing density of the weave, indexed by the âcover factorâ has an important role in defining the ballistic performance. it is determined by the width and pitch of the warp and weft yarns and gives an indication of the percentage of gross area covered by the fabric. in general, fabrics with cover factors between 0.6 and 0.95 are more effective when used in ballistic applications. when cover factors are higher than 0.95, the yarns are typically damaged during the weaving process and when cover factors fall below 0.6, the fabric may be too loose to be protective.  
in the frame of smartpro, a series of woven kevlarâ® fabrics with varying weights and structures (plain weave, basket weave, warp-rib and a combination of diagonal and reverse face warp rib weave) were manufactured and characterized in terms of mechanical properties and cover factors. according to the characterization results, a plain weave kevlarâ® fabric weighing 200 g/m2 and having a cover factor in the suitable range for ballistic applications was selected as basic protective textile.  
  
surface treatments to increase the protective efficiency  
alternative surface treatments were proposed, developed and applied on the aforementioned basic protective fabric. the aim was to enhance the performance of the fabric, which would allow using fewer layers and, thus, developing a lighter panel. the treatments proposed and studied in smartpro were:  
â¢ application of shear thickening fluids (stfs)  
â¢ application of dilatant polymers  
â¢ application of ceramic coatings  
â¢ application of carbide and graphene-coated carbide particles  
â¢ application of crosslinkable, side-functionalized aromatic polymers  
â¢ application of graphene coatings  
more details on each of the above treatments follow.  
  
application of shear thickening fluids  
shear thickening fluids (stfs) exhibit a yield stress fluid and deformable behaviour under ordinary conditions. however, once a strong impact is applied, they turn solid-like as their viscosity suddenly diverges, showing a non-newtonian flow behaviour. hence, according to studies reported in the literature, stfs can be used as aid materials to improve the performance of regular body armours, allowing the wearer flexibility for a normal range of movement, yet turning rigid and resisting penetration under impact.   
accordingly, the work conducted in smartpro aimed to: (1) develop stfs with optimized composition and characterize them in terms of their rheological behaviour and (2) apply the optimized stfs in protective panels, to increase the protection level on an areal density basis.  
different types of particles were considered for the preparation of stfs, including sterically stabilized pmma model hard sphere particles, raspberry-like particles, fumed silica nanoparticles and non-fumed silica microparticles. based on the rheological characterization of the fluids composed thereof, it was decided to focus on stfs based on non-fumed silica microparticles, since they exhibit effective shear thickening effect, while having an original viscosity (under no shear) that allows their handling.  
two approaches were explored for their application in protective panels. the first involved impregnation of the protective fabric with the fluids by padding. following this approach an improvement of stab resistance was observed; however, none of the panels including stf-treated layers satisfied the requirements set in the project. according to the second approach, the stfs were used to soak 3d knitted kevlarâ® fabric (developed and industrially produced in smartpro), which was subsequently confined in plastic bags. the bags containing the stf-soaked fabric could be used as inserts between kevlarâ® fabrics in the protective panel. however, due to the high weight of the stf-containing bags, this approach was not further tested.   
  
application of dilatant polymers  
application of dilatant polymers on the protective fabric was explored through two alternative routes: (1) coating with dilatant powders obtained from a dilatant foam and (2) coating with a dilatant dispersion obtained from a dilatant gum. the dilatant foam is a stf encapsulated into a foam, while the dilatant gum is a polymer exhibiting high elasticity and specific rheological properties, i.e. almost immediate hardening upon impact.   
â¢ coating with a dilatant foam powder: a dilatant powder was obtained from a dilatant foam using milling equipment. the powder was then applied onto the fabric, pre-impregnated with a binder, by electrostatic deposition. the binder aimed to improve the adhesion of the powder to the textile surface. after spraying with electrostatic powder spray gun, a reticulation process of the resin was applied. however, following this approach it was not possible to achieve homogenous dispersion and adherence of the powder on the textile.  
  
â¢ coating with a dilatant compound: a dispersion of dilatant compound was prepared and applied on protective fabrics by different techniques (padding and coating) and process conditions. the resulting coated fabrics were subjected to impact testing following a modification of en 13277-7:2009 standard. although these tests showed higher impact reduction (referring to the impact force received by the reverse textile surface, in respect with the initial impact force applied to the front surface) for the coated fabrics compared to untreated ones, it was not possible to obtain a lightweight stab and ballistic resistant panel using such coated layers.   
  
application of ceramic coatings  
different thermal spray techniques were implemented as surface treatments on aramid-based protective textiles to enhance their protective properties by applying thin ceramic oxide and metallic layers. thermal spray techniques are easy to apply and relatively low-cost, offering the flexibility of depositing layers of a wide range of materials (even very high melting point ones) on a variety of substrates with complex geometries on large surfaces. it is worth noting that this work is highly innovative as very few research teams are working on textiles protective properties improvement using thermal spraying.   
in the frame of smartpro the potential use of atmospheric plasma spraying (aps) and liquid plasma spraying (lps) in terms of layers deposition on textile surfaces was investigated and thermal spray parameters (plasma power, spraying distance, feed rate etc.) were optimized for each material applied. critical aspects that influenced the design of experiments methodology were the very low surface roughness of the selected textiles and the substrate temperature raise during deposition, since thermal spray is a high temperature technique.  
due to the fact that lps requires suspensions as feedstock materials, stability and homogeneous dispersion of different ceramic oxides (al2o3, tio2, sio2) and binary mixtures (60-80 wt % al2o3 - 20-40 wt % tio2, 60-80 wt % al2o3 - 20-40 wt % tio2) was optimized. however, the lps technique proved unsuitable for successful layers deposition due to the necessity of small spraying distance and consequent textile temperature raise.  
the aps technique was used for the deposition of a metallic bond coat layer prior to ceramic oxide layers to promote adhesion of the coating on the textile. the ceramic oxide (alumina) layer that followed was deposited again using the same thermal spray technique. optimization of the critical aps deposition parameters was also performed for the oxide layer. îïwas shown that after deposition the fabric used as substrate remains unaffected, exhibits uniform deposition of both layers and fabric texture is followed by the coatings system. optimization of thermal spray deposition parameters was performed for each deposited layer on the textile substrate. different optimized set of parameters were selected with the aim to maintain the coating adhesion and simultaneously minimize the weight gain of the textile.  
the treated textiles obtained through the thermal spray deposition of ceramic materials were, in fact, successfully used in combination with untreated and alternatively treated fabrics, for the development of lightweight (ca. 5.7 kg/m2) ballistic resistant protective panels. in the frame of smartpro it was not possible to obtain a panel containing ceramic-coated fabrics and exhibiting both protective properties with that weight, even though further trials and assembly combinations could lead to such result.  
  
application of carbide and graphene-coated carbide particles  
the popularity of silicon carbide (sic) for use in lightweight armour systems is increasing rapidly, mainly due to the significant improvement in cost/performance ratio of sic seen in recent years relatively to established materials like alumina. moreover, despite the fact that sic has a high/similar density (3.21 g/cm3) compared to other ceramics like b4c and al2o3, it offers better resistance for impact pressures above 20 gpa (typical value for large ammunitions and impact at high velocities) .   
for the application of the sic particles the simple technology of pad-dry-curing was investigated here, in order to allow easy scale-up of the process at industrial scale. pad-dry-curing also allows the deposition of a thin coating layer, leading to low weight increase compared to other technologies, such as spray coating. since padding requires the immersion of the textile support into a solution, a specific particle/polymer dispersion had to be prepared. aliphatic polyurethane (pu) resins were selected as the most suitable carriers for the particles. a challenge in ceramic coating application is the homogeneity of the ceramic oxide in the polymer dispersion. ultrasonic (us) treatment was used to avoid agglomeration of solids in the liquids and induce fragmentation phenomena which reduce the particle size, ensuring that a large superficial area is available to interact with impact energy, maximising ballistic and stab resistance effects.  
according to previous results, sic dispersion (sic: 10%wt./v; silcosperse: 10%wt./wt. sic; us treatment @20 khz for 20 minutes) was mixed (ratio 1:1) with a commercial pu resin, sancure 898. since energy absorption is one of the most significant parameters in ballistic/antistab performances, the application of ceramic particles onto kevlarâ® substrates was paired with the deposition of a thin nanofibrous layer before impregnation, considering that nanofibers significantly increase energy absorbing capability during impact.  
in the frame of smartpro, sic-coated kevlarâ® fabrics were successfully used in combination with untreated layers for the assembly of protective panels exhibiting both ballistic and stab resistance while weighing 5.76 kg/m2. it is worth noting that, while a process for the production of graphene-coated sic particles was successfully established, the graphene coating did not appear to further enhance the protective properties and was not further explored in the project.  
  
application of crosslinkable, side-functionalized aromatic polymer  
this work involved the synthesis of aromatic polyethers bearing side cross-linkable double bonds with optimized molecular weights, their coating onto selected kevlarâ® fabrics and subsequent cross-linking. in specific, the target was the development of uniform high polymer loading kevlarâ® fabrics followed by a thermal cross-linking procedure in order to further improve the strength and energy absorbing capability of the polymer-coated kevlarâ® fabrics.   
first, the newly synthesized copolymers were optimized in terms of molecular weight to obtain polymers with excellent film forming properties. pilot scale monomer and polymer synthesis (up to 300g) was also accomplished to meet the needs of the project.   
regarding the coating of kevlarâ® fabrics, in order to accomplish high polymer loadings and uniform coating, different methods (such as immersion into the polymeric solution and pad-dry cure) were applied. although pad-dry-cure resulted in uniform coating, the polymer loading obtained was low. on the other hand, immersion of the kevlarâ® fabrics into polymer solution with high concentration resulted in very high polymer loading, but low quality of the coating. thus, an optimization of the conditions (polymer concentration, the number of times the kevlarâ® fabric is dipped into the polymeric solution, etc) was conducted to produce uniform, high polymer loading on kevlarâ® fabrics with improved mechanical properties. indeed, we succeeded to produce kevlarâ® fabrics with satisfactory polymer loading (12-15 wt%) and uniform coating using a homemade set up.   
the thermal cross-linking process was selected among others (e.g. chemical cross-linking) as an easy way of creating an intermolecular polymer network with improved mechanical properties. the presence of propenyl groups enables thermal cross-linking without the need of any cross-linking agent. optimization of the thermal cross-linking conditions in terms of temperature, time and air conditions took place. thus, the kevlarâ® fabrics were thermally treated under inert atmosphere at 260oc for 30 min up to 1h to be efficiently cross-linked.   
lightweight panels prepared using the optimized thermally cross-linked kevlarâ® fabrics with high polymer loading passed successfully both stab and ballistic resistance tests.  
  
application of graphene coating  
multilayer graphene is an exceptional anisotropic material due to its layered structure composed of two-dimensional carbon. having a breaking strength of 42 n mâ1, where a hypothetical steel film of the same thickness would have a breaking strength of 0.4 n mâ1, graphene is more than 100 times stronger than steel . accordingly, it could be used to enhance the performance of kevlarâ® fabrics.   
within the project, a combination of graphene and polyurethane (pu) was investigated, considering its ability to melt and reseal around the path of the projectile as it impacts the surface and passes through the bulk . graphene nanoplatelets having a thickness of 10-30 nm, plane dimensions 20 to 50 î¼m, carbon content over 97 % and bulk density between 0.02 and 0.1 g/cm3 were used. a coating process was used to apply the nano-dispersion.  
thus, graphene (50 wt %) was added to a pu dispersion and then dried and fixed at 60â°c for 1 h. the amount of graphene/pu resin deposited on the fabric is around 20-25 g/m2, while the presence of graphene was confirmed by sem. crock-meter tests (10 cycles) confirmed that the abrasion resistance is improved since there is no detachment of the coating even if the system is more rigid as confirmed by bending rigidity test (bfast= 1300 âµnm).  
  
assembly of the protective panel  
following the application of alternative surface treatments as described above, resulting textiles had to be selected, combined and assembled in protective panels which would provide level iiia ballistic resistance and level 1 stab resistance, while weighing 5.72 kg/m2 or less (target set in the project). the assembly of the protective panel is itself a challenging task, as various parameters have to be defined, including: the type and number of fabric(s) layers, the assembly sequence (i.e. which fabrics are on the strike face and which are close to the body) and the sewing pattern. a key consideration when aiming at both ballistic and stab resistance is to combine rigid layers (which are generally effective in inhibiting penetration by sharp blades, i.e. stab protection) with more flexible ones which contribute to energy dissipation and, therefore, enhance the ballistic resistance of the panel. accordingly, most of the panels developed in the project consisted of treated and untreated layers, the latter constituting the more flexible section of the armour.   
  
testing of the protective panel  
ballistic tests - ballistic tests were performed according to nij 0104.4 on 40 x 40 cm panels. since the target was to reach level iiia ballistic protection, the tests were performed with a 9-mm caliber fmj (124 g) at a velocity over 435 m/s. according to the standard, a panel passes the test if both following conditions apply: (a) the panel is not perforated and (b) the back-face-signature (trauma) is lower than 40 mm.  
stabbing tests - stab resistance was assessed according to nij 0115.0 under the conditions for protection level 1. accordingly, each panel was first hit with a knife at an energy of 24 j. provided that the penetration of the knife was less than 7 mm, the panel was hit again at an over strike energy of 36 j. at this second strike, the penetration of the knife should be lower than 20 mm.  
  
results  
among the many different types of panels tested, several passed either the ballistic or the stabbing test but failed the other, while only two panels successfully passed both tests. one of them consisted of untreated kevlar layers and layers treated with nanofibers, sic particles and pu and weighed 5.76 kg/m2, while the other consisted of untreated kevlar layers and layers treated with crosslinked polymer and weighed 6.00 kg/m2.   
  
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# SABIP

Project Acronym: SABIP

programme & topic: FP7-IDEAS-ERC ERC-AG-LS9

Most frequent returning words in objectives:

* ('silk', 14)
* ('silks', 14)
* ('insights', 7)
* ('protein', 6)
* ('materials', 5)
* ('properties', 5)
* ('study', 4)
* ('studies', 4)
* ('novel', 4)
* ('relationships', 4)
* ('products', 4)
* ('analysis', 4)
* ('models', 3)
* ('value', 3)
* ('range', 3)
* ('producers', 3)
* ('establishment', 3)
* ('polymers', 2)
* ('aspects', 2)
* ('detail', 2)
* ('time', 2)
* ('fibres', 2)
* ('filaments', 2)
* ('water', 2)

silk is a non-perishable agricultural product with an unparalleled history as high-value and wealth-creating fibre and textile. our erc funded study silks as biomimetic ideals for polymers set out to scientifically examine specific aspects of silks in detail while at the same time probing the possibilities of silks and silk derivatives as commercial materials in the 21st century. our studies confirmed that silks are remarkably tough fibres as well as materials that could be ecologically sustainable if properly managed. filaments that can match the best of man-made fibres are produced with water as the solvent, with pure proteins as the major structural components and are all processed under benign ambient temperatures and pressures. silks are biocompatible and biodegradable, which makes them both important medical materials as well as models for designing novel, fully sustainable polymers. in addition silks, being protein based, provide unique models for protein folding and some of the fundamentals of protein structure/properties/function relationships. finally, as non-perishable agricultural products, silks are notable for combining good land-use with high socio-economic value.  
  
with all these interesting and important silk properties in mind, our study focused on 4 closely interwoven themes. firstly we explored the natural diversity of silks from many taxa ranging from spiders and insects to shrimps and bees. secondly we tested the materials properties of a wide range of silks in great detail using a unique combination of state-of-the-art analytical equipment and insights. thirdly we used advanced mathematical modeling to theoretically analyse the full hierarchy of a silkâs structure-property-function relationships obtained from empirical measurements. fourthly we interacted with many producers of silks and manufacturers of silk products in order to further the sustainable use of silks and the development of novel silk products based on scientific insights. significant progress was made in all four areas demonstrated by selected exemplary studies. in the field of bio-exploration we discovered and analyzed a novel marine underwater silk that combines aspects of spider thread and barnacle glue. the study of unusual nano-scale filament or permanently liquid-droplet silks led to the discovery of specialist adaptations with important wider implications. a wide range of silkworm-moth cocoons provided novel and highly technical insights into the construction of outstanding composite material with commercial applications. a new way to unravel the cocoons led to a patent granted with consequences for silk industries in emerging markets.  
  
our materials testing laboratory provides a superb state-of-the-art analysis facility for bio-materials where, for example, millimeter lengths of micron-scale filaments (or mm cubes of biopsy or composite samples) can be analyzed over the full range of their mechanical, thermal and chemical properties. insights gained from such studies demonstrated the importance of water only for the flow properties of un-spun silks but also for the properties of the fully formed thread. importantly, these studies also showed that native (natural) pre-spinning silk behave very different (by orders of magnitude) from silk-solutions that had been obtained by dissolving spun silks. this observation led to deeper understanding of silk-protein folding, which is leading to the establishment of silk proteins as models to study fundamentals of protein folding. our modeling approaches further facilitate the establishment and analysis of hypotheses pertaining to protein structure-properties-function relationships based on empirical data. importantly, this research on silk protein conformations and their transitions demonstrated the value of a tightly interactive group effort integrating experiment and modeling when studying structure-function relationships in a biomaterial.  
last but not least, throughout the grant we have pro-actively engaged existing producers as well as actual and potential end users of silk products. this allowed us to interactively communicate our scientific discoveries while at the same time acquiring important insights into the needs and technical requirements of the wider silk market. a much appreciated erc proof of concept grant allowed us to successfully promote the commercial applications of our fundamental insights. this includes the establishment of a data-base and an extended life cycle analysis of service to the global silk industry. our concept of an eco-swot analysis will allow the defining, branding and marketing of âsustainable silksâ in europe by allowing researchers, producers and users to forge valuable links between academic insights and commercial realities in a market that is already adding ca â¬80bn value to the ca â¬2bn of raw silk.

# BioBuild

Project Acronym: BioBuild

programme & topic: FP7-NMP EeB-NMP.2011-1

Most frequent returning words in objectives:

* ('materials', 56)
* ('energy', 44)
* ('fibres', 40)
* ('resin', 27)
* ('treatment', 23)
* ('project', 22)
* ('properties', 21)
* ('fibre', 21)
* ('treatments', 21)
* ('performance', 20)
* ('building', 19)
* ('construction', 18)
* ('fire', 18)
* ('task', 18)
* ('flax', 15)
* ('water', 13)
* ('coatings', 13)
* ('resins', 12)
* ('milestone', 12)
* ('work', 12)
* ('biocomposite', 11)
* ('resistance', 11)
* ('case', 11)
* ('effect', 11)

executive summary:  
biobuild was a three and a half year project funded by the european commission. the aim of the project was to develop biocomposite materials for use in construction applications which would have a lower embodied energy than existing construction materials. the project was coordinated by netcomposites ltd who assembled a consortium of thirteen partners involved in the research, development and manufacture of biocomposite materials.  
  
embodied energy is the sum of all the energy required to produce a component from raw materials. it includes the energy needed to extract or harvest the materials, refine them, convert them to intermediates and then manufacture parts. this is then associated with or âembodied inâ the final component. the energy used by a building during its life is only one to three times that used to construct the building (including the energy needed to produce the construction materials). thus there is a need to reduce the energy embodied in construction materials.  
  
this can be achieved by using composite materials and biocomposites in particular. biological materials absorb carbon as they grow and so have a far lower global warming potential (gwp) than materials made from minerals and petrochemicals. wood is widely used as a building material but is expensive and is not always harvested in a proper sustainable manner. biocomposites can be produced from crops grown in a sustainable way with minimal impact on food supply.  
  
the use of biocomposites is not widespread as there are concerns about their long term durability and resistance to fire. however, wood can also degrade and burn, yet mankind has learnt design and technical solutions which mitigate these shortcomings.  
  
biobuild produced full scale building components using biocomposite materials. this was done to prove that such components could be made and would have properties that would enable them to comply with the requirements of the application. the parts were subjected to full scale component tests. panels and coupons of the materials were made and were tested in the laboratory to demonstrate their performance. single burning item fire tests were conducted.  
  
the materials made in biobuild used jute and flax fibres. the resins were either a part bio-based polyester resin or a polyfurfuryl alcohol resin. a fully biobased polyester resin is not currently possible as there is no cost effective route to synthesise styrene from a biological precursor and the styrene replacements are not proven. polyfurfuryl alcohol resin is derived from agricultural wastes rich in hemicellulose. it has a very low gwp and has no impact on food supply. the project developed fibre and resin treatments to reduce water swell, increase mechanical properties and improve fire retardance. coatings were also employed.  
  
biobuild was able to produce biobased materials which achieved euroclass b in sbi tests and also had the required mechanical properties and weather resistance to enable their use in construction applications. it was shown that these materials had lower embodied energy than competing materials. in the case of pfa based composites the target of a 50% reduction could be achieved.  
  
project context and objectives:  
the aim of the biobuild project was to use biocomposite materials to reduce the embodied energy in building facade, supporting structure and internal partition systems by at least 50% over current materials with no increase in cost. this will lead to a step change in the use of sustainable, low carbon construction materials, by replacing aluminium, steel, fibre reinforced polymers (frp), brick and concrete in new-build and refurbished structures.  
  
the construction industry in the eu provides enormous benefits to society by providing homes, infrastructure, public and commercial buildings and the built environment in which we live. it is also the biggest provider of jobs in the eu, employing 16 million people and contributing over 10% of the gdp for the eu27 countries. however, it follows that it is also an enormous consumer of energy. the construction industry is responsible for about 40% of the total eu energy consumption, 36% of green house gases and 50% of the co2 emissions. it is now recognised that energy use and the resultant generation of co2 emissions is having an effect on the global climate and there is international agreement that co2 emissions must be cut in all industries to mitigate the effects. it follows that the construction industry can make huge contributions to these reductions.  
  
therefore, there is now a focus on the analysis and subsequent reduction in the embodied energy of buildings, led initially by legislation and environmental targets but increasingly driven by the commercial need to compete on environmental credentials. embodied energy is the sum of all the energy required to produce a component from raw materials. as the science of life cycle analysis is relatively new the categorisation of embodied energy is still being refined but the principle is that it includes the total energy used in the lifetime of a product. it includes the energy needed to extract or harvest the materials, refine them, convert them to intermediates and then manufacture parts. this is then associated with or âembodied inâ the final component. embodied energy is distinct and different to inherent energy which is the energy that would be released when a material is burnt.  
  
embodied energy can be used as a measure of the co2 emissions associated with the manufacture of materials or components. the actual level of emissions depends on the energy mix used (nuclear, coal, gas etc.). traditional building materials such as bricks, concrete, steel and aluminium have a high embodied energy because of the high temperatures required to produce these materials.  
  
embodied energy is usually expressed in terms of mj/kg. this is a simple unit for the purposes of calculating the embodied energy of a material but when comparing the embodied energy of one material against another, a comparison on a mass basis is not valid. what must be considered is the functional unit â the amount of material needed to achieve the same technical performance. to produce house bricks requires 8 mj/kg whilst it needs 79 mj/kg to produce polyurethane foam. however, polyurethane foam is much less dense than brick and has a far lower thermal conductivity so adding 50 mm (2 kg/m2) of polyurethane foam to a 225 mm brick wall (382 kg/m2) reduces the u value from 1.7 w/m2k to 0.4.  
  
in the 1970s the energy required to heat a building during its life was 10-20 times the energy embodied in the construction materials. however, improvements in building insulation and boiler performance etc. have led to a reduction in the amount of energy needed to heat a building whilst at the same time there has been an increase in the embodied energy of the materials used. therefore, the energy needed to heat the building is now only one to three times that embodied in the fabric of the building. (âbuilding materials and co2: western european emission reduction strategiesâ, d.j. gielen. dutch national research programme on global air pollution and climate change netherlands energy research foundation; ecn project number 7.7018). to reduce the overall environmental impact of a building there is a need to reduce the energy embodied in construction materials.  
  
facade systems are used in a wide variety of buildings such as housing, industrial units, schools, airports and hospitals, their primary use being to protect and insulate the internal structure. internal partitions are used to divide space, carry utilities and provide thermal and acoustic insulation. the current materials used, such as aluminium, steel, brick and concrete, are energy intensive in their raw material production, forming, installation and disposal and therefore have high embodied energy.  
  
an alternative material is frp, which already plays a significant role in new, efficient construction applications and benefits from light weight, good formability and simple manufacturing technologies, thereby enabling low material content structures, low transport costs and innovative design. however, the resin and glass fibre used in their manufacture have non-renewable petro-chemical and mineral origins which are energy intensive in their synthesis, and the cost of frp systems can be higher than those based on traditional materials. biocomposites can overcome the drawbacks of conventional frp, whilst maintaining the aforementioned benefits, because they are based on natural fibres and bioresins which have very low embodied energy and are low cost.  
  
biocomposites have a typical resin and reinforcement structure, as used in frp, but the sources of the raw materials are bio-based, renewable and sustainable. the resin in this project will be derived from the hemicellulosic part of agricultural wastes (furan resin) and from waste cashew nut shells (bio-epoxy resin). furfuryl alcohol, the key raw material for the production of furan resins, has a global warming potential (in terms of kg-co2-eq) of 0.60 compared to unsaturated polyester resin at 7.5. the reinforcement fibres will be derived from flax and jute plants which can grow in poor soil and have a long history of industrial application.   
  
flax fibres have mechanical properties comparable to those of glass fibres, whilst having approximately half the density. recent research has shown that flax and other bast fibres have significantly lower environmental impact than glass, in particular in the areas of climate change, ozone depletion, toxicity and eutrophication (green guide to composites, bre and netcomposites 2004, isbn 1 86081 733 5). the energy required to produce hemp and flax fibre suitable for composite applications is lower than that needed to produce glass & carbon fibres. the energy required does depend on the form in which the fibres are used (ud tows, random mat, woven fabric). reliable figures for natural fibres are difficult to obtain as there are a number of different assumptions which need to be made with regards to yields, fertiliser use etc. values ranging from 15-52 mj/kg are reported, which is still lower than glass (55 mj/kg) and much less than carbon fibre (130 mj/kg). jute provides similar environmental credentials at a lower cost and reduced mechanical performance but with better moisture resistance.  
  
biocomposites are already used in a number of commercial applications, most notably in automotive interior parts. unfortunately biocomposites have some shortcomings which may limit their use in certain applications. they may not be as strong or as stiff as conventional materials, they are combustible and they can be degraded by the action of water, sunlight or microbes. however, much of the same can be said of wood which has been used as a construction material since prehistory and mankind has developed strategies for overcoming the shortcomings of timber.  
  
the biobuild project consortium was established to develop biocomposite materials and construction products with a life span of at least 40 years, by protecting the natural fibres with novel treatments and coatings and improving the overall biocomposite properties.  
  
scientific & technical objectives  
  
the overall aim of this project was to create new biocomposite construction systems which could replace the high embodied energy materials currently in use, significantly improving the environmental impact and sustainability of the european building industry. within this broad aim three primary objectives were set:  
  
â¢ to develop large, low embodied energy flat or shaped, biocomposite panels which can be used as external or internal cladding for new or re-developed buildings.  
â¢ to develop low embodied energy continuous biocomposite profiles which can be used in external facade or internal support structures.  
â¢ to integrate the elements into a cohesive and efficient construction system and prove the technology by means of full-size demonstration installations.  
  
to achieve these primary objectives, the project was broken down into a coherent series of smaller tasks, each with related technical objectives:  
  
â¢ gather and analyse relevant current and draft standards, legislative requirements and european targets and use them to set parameters for the project case studies (milestone 1).  
â¢ after some initial work the feasibility of a combined fibre and resin system will be evaluated (milestone 2)  
â¢ at an early stage an environmental quick-scan of proposed technologies will be carried out in order to inform and direct the choices of materials and processes. (milestone 3)  
â¢ the integration of the proposed materials and parts (sheets, profiles, panels) will be reviewed at an early stage to inform the design and decision making process (milestone 4)  
â¢ optimise biobased resin systems for long-term durability and fibre compatibility and optimise flax and jute fibres and continuous yarn, mat and textile formats in order to replace glass fibre in composite manufacture (milestone 6).  
â¢ combine biocomposites with coatings, sandwich materials and adhesives to generate construction materials with improved functionality (milestone 5).  
â¢ manufacture new composite parts and optimise processing and process control using a wide range of established composite manufacturing methods  
â¢ assess the mechanical properties, the fire performance, the weathering and environmental impact of the developed composite materials (milestone 7).  
â¢ build full-size but partial assemblies for internal and external applications to optimise the integration of the design, materials, performance and functionality. these will be used for testing, demonstration of the functionality and industry feedback (milestone 8).  
â¢ carry out tests to current standards and certify the products where possible. the objective is to create materials and systems which achieve standards comparable with current technology (milestone 9).  
â¢ manufacture large tools and parts to construct full-size demonstrators to be used as testing installations and for demonstration. the ultimate objective is to combine all the new materials into a representative building project (milestone 10).  
â¢ carry out continuous, comprehensive environmental evaluation and monitoring which will inform the decision making process for the materials and processing. an eco-efficiency impact evaluation will be made and will feed out to the lca community as well as support the project (milestone 11).  
â¢ connect with industry, policy makers, authorities and associations to keep realistic and practical goals and to disseminate within the european construction industry and the end-users within the industry (milestone 12).  
  
project results:  
wp1 â performance and standards requirements  
  
task 1.1: gather appropriate standards  
  
european and national standards and regulations relevant for biocomposites in the building industry were researched and collated by 3xn, lnec, arup, tno and shr. guidance about the general performance of biocomposite materials in the context of building industry applications and input about was provided by netcomposites. this task was run in parallel to wp5 which relates to the design of the case studies the outcome was to select the following types of building elements as case studies:  
â¢ external wall panels (ewp)  
â¢ external cladding kits (a rainscreen cladding system) â the eck  
â¢ internal partition kits (ipk)  
â¢ suspended ceiling kits (sck)  
  
the relevant harmonised european standards (en) or guidelines for european technical approvals (etag) relevant to the chosen case studies were considered. the primary aim of the project was to develop more sustainable building products, so assessments of environmental, health and cost issues were required. the work therefore covered a review of relevant cen & iso standards in this area.  
  
the results were compiled into a comprehensive document that specified all of the relevant performance requirements, standards and associated tests to follow in the development of the case studies mentioned above.  
  
task 1.2: identify the key materials and processes  
  
the base materials to be used in the project were selected, along with a limited selection of benchmark materials against which they would be assessed. these benchmark materials were materials conventionally used in similar applications.   
  
the materials to be used were specified. this included suitable types of reinforcement: flax and jute fabrics supplied by netcomposites, (figure 1), biobased resins (bio-polyester & polyfurfuryl alcohol) from tfc (and dsm prior to their exit) and core materials, primarily cork supplied by amorim (figure 2). the project identified suitable treatments to be developed to enhance durability and other key performance requirements, such as fire performance. the selection of treatments was led by kul, ivw & shr, with some input from cimteclab before they exited the project. suitable manufacturing methods were identified for all of the proposed materials. this was led by the manufacturing partners (acciona and exel, with additional input from ivw & netcomposites).  
  
task 1.3: specify desirable case studies  
  
there was a broad overlap between this task and work package 5, as it was necessary to identify the case studies and do initial concept designs in order to specify them. 3xn & arup led this activity in consultation with the other partners. in selecting and developing the case studies, and identifying appropriate performance requirements to specify, existing products made from conventional materials were chosen as benchmarks. the capabilities and expertise of the partners was also considered, resulting in a decision that a biobased window frame was not a worthwhile case study and a suspended ceiling kit was selected instead.  
  
task 1.4 draw up target properties and characteristics for the system components  
  
this involved quantifying appropriate performance requirements derived from the standards, building regulations and directives gathered in task 1.1. all partners in the consortium were consulted to identify and understand the materials properties and materials processing factors linked with the different performance requirements to be specified. this information was used to influence the design of the case studies and identify the relevant parameters associated with the manufacture of the parts. the output from this task was a detailed specification defining quantified performance requirements. an extensive deliverable was compiled by 3xn and at the end of the project it was agreed that this document could be made public.  
  
wp2: reinforcement and matrix development  
  
the global objective for wp2 was the modification of the resins and fibres in order to improve the combined properties. a key aim is improving the moisture resistance properties and the durability of bio-composites through a selection of fibre treatments. simultaneously, an increase in moisture resistance and fire retardance and a decrease in porosity and degradation are targeted through a development of the bio-resins. a third target is the optimization of the fibre-matrix interface towards improved composite performance.  
  
task 2.1: fibre treatment to reduce direct and indirect moisture uptake  
  
the work started by measuring the baseline properties of the untreated fibres. a range of treatments were investigated. various strategies were applied by shr, ku leuven and ivw. the strategy behind all of the treatments was threefold. on the one hand, fibre treatments were aimed to make the fibres more hydrophobic by nature. this strategy was primarily followed by shr (acetylation treatments) and yielded promising results for both flax and jute fibres. on the other hand, fibre treatments with the possibility to increase the interphase strength between the natural fibres and the furan or bio-polyester resins were looked at by ivw and ku leuven. in the first part of the period, the latter two institutes also searched for fibre treatments to compatibilise the natural fibres with bio-epoxy resins from cimteclab. this work was abandoned due to the bankruptcy of this partner and the results of the quickscan which demonstrated that the proposed bio-epoxy composite did not produce much reduction in embodied energy  
  
other treatments studied by ku leuven were, mercerization techniques, aps coatings and plasma treatment. ivw focussed primarily on the use of bio-derived cashew nut shell liquid varieties to improve the interphase strength of the different composite types.   
  
task 2.2: fibre treatment to improve durability, fire retardance and biodegradation resistance  
  
this included the appliance of fibre treatments to improve durability, fire retardance and biodegradation resistance. again various (different) strategies were adopted and investigated by ku leuven, ivw and shr. ku leuven focussed on the durability increase by strengthening the internal structure of the flax fibres. research strategies were developed and attempted to increase the internal interphase strength of flax fibres by treating the fibres with specific cross-linking chemical agents. the idea behind this technique is that hydrophilic molecules that are inherently exposed within the reinforcing flax fibres are prevented from interacting with water molecules in the atmosphere by covalently binding them to chemical precursors. therefore, the resistance of the flax fibres towards external environments is increased, swelling is reduced, damage is retarded and as a result durability is increased.   
  
an approximation of the effect of different chemical treatments on the interfacial shear strength has been clarified by performing transverse three-point bending tests on composite specimens. the effect of 3-aminopropyl-tri-ethoxysilane (aps) in small and medium concentrations on the interfacial properties has been explored, both in pure form and in combination with a mild alkali treatment (4 wt%). in addition to this, the effect of heavy alkali treatment (18 wt%) on the fibre properties was also established. finally, a treatment with di-methylol-di-hydroxyethyleneurea (dmdheu), an industrial process already readily established as an anti-wrinkling agent, was examined. regarding the heavy alkali treatment, longitudinal tensile tests on technical fibres indicate a decrease in youngâs modulus by 17% and a decrease in longitudinal tensile strength of 23% are obtained. as the deterioration of the fibre mechanical properties was too severe, this chemical treatment was discarded.   
  
the remaining treatment combinations were examined based on their effect on the transverse 3-point bending strength, as depicted in table 15. from this table, it becomes clear that both a mild alkali treatment and treatment with dmdheu lead to an improvement in the transverse 3-point bending strength. this was expected as alkalization treatment presumably removes most of the waxy essences that cover the surfaces of raw flax fibres. this ensures that hydroxyl groups become present at the surface, which increases the amount of reaction sites with the epoxy matrix. as a second effect, the fibres tend to become rougher, which also increases the interfacial strength due to mechanical interlocking. aps generally weakens the positive effect of the alkalization treatment. the combined effect of the positive treatments (naoh and dmdheu) is still to be explored.  
  
ivw conducted work on the treatment of flax fabric yielding water-resistant âgreenâ coatings or graftings on the fibersâ surface using bio-derived phenalkamines (phalk) and water glass (wg) of mineral origin. water glass, as a very cheap highly alkaline polysilicate precursor was applied as mercerisation agent yielding improved fire resistance. it is also well known that mercerisation of natural fibres usually results in their improved mechanical properties.   
  
liquid phenalkamines derived from cardanol (distillation product of cashew nutshell liquid) bear high-reactive amino groups, which are able to react with carboxylic and/or methylol groups of the natural fibres. the super-hydrophobic character of the long aliphatic chain in the structure of phenalkamine was employed to improve hydrophobicity of the fibers and to enhance their compatibility with the (bio)epoxy matrix (especially containing cardanol based components). in addition, improved durability and some bioactivity of phalk-treated fibres were expected. combined wg and phalk in sequential combinations were also prepared.  
  
for the treated fabrics, a significant change of their chemical structure due to the chemical reaction between functional groups of fibers and wg and phalk was confirmed by ftir spectroscopy. moreover, microscopic investigations demonstrate that fiber surface topography changes due to the modification. at the same time, after combined treatment, a second tg was observed indicating the formation of an organic-inorganic hybrid polymer network. it was found from dsc data that wg modification increases glass transition temperature (tg) of fibers. on the other hand, wg treatment decreased thermal stability of treated fibers, but improved char-yield, whereas phalk showed no significant effect on thermal properties. it was found that phalk-type has significant influence on the water resistance. higher reaction temperature also resulted in lower water uptake values.   
  
ivw and shr also focussed on the fire retardance of the composites by investigating the effect of applying fibre treatments. amongst others, formulations of phosphates and aluminium-tri-hydrates were looked at. most of the formulations succeeded in elevating the fire behaviour of treated flax fibre composites, although not so successfully as the investigated coatings from work package 3.  
  
although a number of treatments were identified which gave some improvement in fibre properties, it has also been proven that it is inadequate to test fibre properties alone as behaviour in the composite can be different. for example, ivw showed that the fibres could be made hydrophobic by cardanol treatment but when these were used in a laminate the composite still exhibited water swell. further, some treatments made the fabric rigid and this limits further processing.  
  
the sequence in which treatments are applied is very important. the effectiveness of a treatment also depends on the resin used.  
  
alkali treatment is good at removing waxes etc. from the surface of the fibres and so increase adhesion to polar resins but it is important that the fibres are properly washed to remove all alkali as long treatments weaken the fibres. an alkali wash followed by treatment with furfuryl alcohol gave a very large increase in transverse three point bend strength in a flax-pfa laminate but in the polyester resin laminates there was no measured effect of the alkali wash.  
  
plasma treatment of the fibres was not effective at raising the strength of the bond to the resin. this was unexpected. it may be possible that since the resins and fibres are polar the plasma treatment is unnecessary.  
  
of the various treatments examined for reducing moisture uptake it was found that acetylation was the most effective, particularly when it was applied to jute fibres. acetylation was deemed most suitable for scaling up.  
  
water glass coating was the best treatment for reducing the ignitability of the fibres but to achieve the desired performance a very thick coating had to be deposited on the fibres thus making the fabric unsuitable for pre-pregging.  
  
task 2.3: resin and composite benchmarking  
  
broad screening work on the development and characterization of the biobased resins was performed. moulding trials were carried out by netcomposites, ivw & kul to create a series of test plaques from non-bio (e.g. traditional epoxy and polyester resins), part-bio (e.g. partially biobased epoxy and polyester resins) and full-bio resins (polyfurfuryl alcohol), combined with glass fibres or natural fibres. unidirectional composites were made first, in order to create benchmark data on the most fundamental composite properties. laminates were then made from woven fabrics & tested.  
  
these plaques provided valuable early data on mechanical, thermal and acoustic properties which was fed into wp5. they also allowed a quick assessment of some processing by the environmental experts tno.   
  
task 2.4: resin property development  
  
task 2.4 dealt with the development of resin properties. cimteclab & dsm were supposed to contribute to this task but their input was limited as both organisations exited the consortium shortly after the end of the first year. the majority of the work therefore fell to tfc. it included the development of pfa varieties with improved fire performance, water resistance and facilitated demoulding. to improve the fire retardance of the pfa base resin, insoluble inorganic polyphosphates were added to the resin. up to 15 wt% could be mixed in the resin system without significant variations in the curing cycle. to decrease the moisture absorption of the furan base resin, cashew nut shell liquid was added to co-react with the oligomeric furans. cashew nut shell liquid was added at up to 10 wt% without significant alteration of the curing behaviour of the pfa resin. it was shown that this blend increased the hydrophobicity of the resin, therefore reducing the moisture absorption. finally, a variant was made with an addition of micronised thermoplastic poly-methyl-methacrylate particles. it was shown that up to 5 wt% of particles could be introduced without significantly changing the curing characteristic of the neat resin. this gave increased shielding of natural fibres against moisture and uv in external environments.  
  
wp3: integration of coating, joining and sandwich technologies  
  
this work package has as specific objectives the development of:  
â¢ in-mould coating, developments of current gel-coat (resin based ) systems  
â¢ post-moulding coatings such as paint, nano-coatings, films or laminates  
â¢ joining technologies such as adhesives or mechanical assembly methods  
â¢ sandwich structures with bio foam or cork, for mechanical, thermal and acoustic improvements  
  
task 3.1: in-mould coatings  
  
this task set out to identify if an in-mould coating was necessary, or even applicable, to the composites structures that the biobuild project intended to develop. these types of coatings were intended to be integrated in the manufacturing process as a method to improve surface quality of the part, to provide a barrier against degradation caused by uv exposure, reduce water uptake, offer flame retardance, wear protection, and be a decorative element.  
  
since gelcoat application is an additional manufacturing operation it became necessary to verify if a biobuild composite structure would benefit of having such type of extra layer thus leading to an early test phase that proved to be vital to incorporate these elements. test plaques were prepared by shr and netcomposites. both weathering (shr) and fire performance tests (lnec & shr) showed the need for a coating to protect uncoated composites. deliverable 3.1 described the results of accelerated weathering tests proving the need for a coating. an example of the degradation which can occur on an unprotected panel is shown in figure 3.  
  
deliverable 3.1 also described the results of ignitability tests and demonstrated the need for a fire protective coating too. it was established that no bio-based in mould coating could be developed or purchased for use in conjunction with the biocomposites developed in the project. there was also no one coating which could provide both adequate fire and weather protection. thus it was concluded that applied coatings would be required and hence work focused on these.  
  
task 3.2: applied coatings  
  
this task had the objective of evaluating the compatibility of market available coatings such as paints, varnishes and films with biocomposite materials and also to evaluate the consequent impact on overall performance. main testing procedures focused on determination of water uptake, on the impact that sealing the edges of the composites panels has on water absorption, on weathering, and on fire behaviour. the results of this work were reported in deliverable 3.2.  
  
in summary the results showed that by applying intumescent coatings the fire behaviour of the both the biope and pfa laminates can be improved ...

# FIBRALSPEC

Project Acronym: FIBRALSPEC

programme & topic: FP7-NMP NMP.2013.2.1-1

Most frequent returning words in objectives:

* ('carbon', 66)
* ('production', 37)
* ('lignin', 32)
* ('fibres', 31)
* ('fibre', 30)
* ('properties', 27)
* ('process', 26)
* ('project', 25)
* ('fibers', 23)
* ('precursor', 21)
* ('composites', 20)
* ('stabilization', 20)
* ('cost', 19)
* ('precursors', 19)
* ('materials', 18)
* ('thermal', 17)
* ('chemical', 16)
* ('fibralspec', 15)
* ('fiber', 14)
* ('treatment', 14)
* ('waste', 14)
* ('applications', 13)
* ('work', 12)
* ('results', 12)

executive summary:  
engineers are constantly pushing the boundaries, aiming to design composites structures by carbon fibers (cfs) with reduced cost, as well as, with improved mechanical properties. after more than 5 decades of research, a growing industry with a multitude of applications has been established and the need on new precursors that not derive from petroleum has been revealed. this requires a novel approach that introduces the significant challenge of production of cfs from "greenâ precursors and manufacturing of fibre-reinforced composites via ecofriendly-production techniques. fibralspec developed innovative processes with streamlining and improved control, through unit for continuous pan-based carbon fiber pilot production. green precursors of cfs based on lignin based blends have been synthesized since lignin has attracted significant attention as an alternative carbon source for conversion to cfs due to materialâs abundance, high carbon content, low cost as byproduct of paper industry and renewable nature. the quality of polymer fibers spun by lignin depends on the spinning method and chemical modification of raw material. however, the improvement of lignin fiber spinning technologies has now reached a limit and new approaches are necessary to be developed based on chemical modification and functionalization. fibralspec also investigated the enhancement of mechanical performance of cfs composites by changing their structure, physical and chemical properties for enhancing of their service characteristics and opening of new functional possibilities of their applications. different types of plasma processes were implemented for the surface treatment of carbon fibres, in order to analyse their advantages and disadvantages. within this framework electrochemical treatment and subsequently electropolymerization onto cfs surface was applied in order to improve adhesion between cfs and matrix through wetting improvement. the modified fibers exhibited improved wetting properties in epoxy resin whereas the resulting modified carbon fiber composites demonstrated a significant increase in the ultimate tensile strength revealing enhanced bonding at the fiber matrix interface compared to the composite with pristine cfs. fibralspec also addressed the issue of production of cfs with enhanced properties by nanoprofiling and nanomodification of their surface using nanoparticles produced from plant raw materials. with nano-fibres becoming an increasing field of interest, ability to control and align the fibres produced during the electrospinning process has emerged as an area that has received much interest. a novel approach of electrospinning was applied and a unique mechano-electro-spinner (mes) has been designed, constructed and commissioned with a potential to be used in fields of application such as carbon fiber industry, polymer/composite industry and textile industry. the work on the fabrication of prototypes of advanced flexible supercapacitors was realised in different steps including determination of the specific concentration of carbon nanofibers (cnfs) mixtures (produced within fibralspec) to achieve the best results, fabrication and testing of the produced devices. the technology for supercapacitors based on cnfs has been already up-scaled within the project and practices of interest for electronics, aviation and automotive industry have addressed during the last four years. the existing concept ârapid deployment secure emergency shelter-fibreglassâ (rdses-fg) which is designed and developed by applying traditional composite manufacturing techniques has been further exploited; employing the use of carbon fibre, the unit mass has been reduced while at the same time increasing rigidity, durability and end user usability, resulting in rapid deployment secure emergency shelter carbon fibre (rdses-cf). as for recycling and used of recycled cfs, new techniques have been used to provide commercially-relevant products that are manufactured from waste carbon fibres. mathematical modeling was conducted so as to determine properties of cfs and composites, together with cost modeling; life cycle assessment assisted possible commercial risks that were continuously estimated during the project and quantify/assess the environmental impact of the used materials.   
project context and objectives:  
carbon fibre composite materials are becoming nowadays more and more part of our lives. after more than five decades of research, cfs and their composites have reached maturity and they are currently not just a âhigh-endâ costly solution for low rate production, but represent a growing industry with a multitude of applications. the cf composites are key elements of smart material systems and structures.  
   
properties such as light weight, high strength, low stiffness, smartness, their dual use and more, makes these materials more and more attractive to various industrial sectors such as transport, electronics, construction, and many other sectors.   
  
their success is due to their high strength-to-weight ratio and to the fact that in composites they exhibit a combination of valuable properties that may provide a solution in complex problems of materials science and technology. in 2010 their production was around 75,000 tons per year, with expected growth rate of around 7 % for the following five years. some of their most important applications are in the sports and leisure industry with articles for many sports (tennis racquets, golf clubs, bicycles etc.), in the aerospace industry (the newest and largest commercial airplanes, boeing 787 and airbus a380, have a large part of their airframe built using carbon fibre composites) and for the blades used in wind turbines. the most important precursor (in terms of production volume) is polyacrylonitrile (pan) fibres; pan-based carbon fibres represent more than 70 % of the total cf production. a point to note here is the supply and availability of cfs in the future where there is a need for the eu states to be independent of the current supply chain. moreover, there is also a need to consider precursor for cf that are not derived from petroleum.   
on this background the european commission, in the nmp.2013.2.1-1. programme, called for research proposals challenged to address key technological issues such as the development of new precursors, new processing routes and functionalisations for carbon fibres. the key points of the topic addressed within fibralspec project are described below:  
  
â¢ technical content/scope: the use of carbon fibre based composites is of major importance in many industrial applications: transport, aerospace, electrical (li-ion batteries, supercapacitors), pressure vessels, high cost of carbon fibres. research is therefore needed to allow the opening of new ways for the industrial production in europe of carbon fibres as well as their functionalisationfunctionalization for targeted applications, and at affordable cost.  
â¢ proof of concept in terms of product and/or process should be delivered within the project, excluding commercially usable prototypes, but convincingly proving scalability towards industrial needs.   
â¢ non-destructive techniques for the characterisation of fibres at the various processing steps and of functionalised fibre products may also be addressed.   
â¢ dedicated modelling of process and properties, qualification, standardisationstandardization and/or the production of (certified) reference materials may also be addressed as an integrated part of the research proposal.   
â¢ life cycle assessment (lca) of the new processes or materials used, their energy efficiency, as well as environmental and safety issues and recycling should be addressed.   
  
in accordance with the overall concept presented above, the project has had the following aims and objectives:  
â¢ the improvement of production of carbon fibres from "green" precursors such as lignin and renewable resources and control of precursor oxidation treatment   
â¢ the manufacturing of fibre reinforced composites via eco friendly-production techniques  
â¢ the functionalization of cfs mainly focused on cost reduction, mechanical and chemical property improvement  
â¢ the use of the reinforced composites in different applications, such as: flexible supercapacitors and rapid deployment secure emergency shelters  
â¢ as for recycling and used of recycled cfs, new techniques have been used to provide commercially-relevant products that are manufactured from waste carbon fibres  
â¢ the application of lca to quantify the green credentials of the reuse and recycling strategies from the start -precursor development-, till the carbon fibre waste.  
â¢ testing of laminates and prepregs production based on the new developed carbon fibres followed by manufacturing of laminates/coupons and high-performance filament wound tubes are also foreseen  
â¢ mathematical modeling has been conducted so as to determine properties of cfs and composites, together with cost modeling  
  
fibralspec project is divided into 11 major major workpackages work packages (wps) (figure 1). these constitute the main work breakdown structure of the project, gathering together the major groups of activities to be carried out. the overall structure is shown in the figure 1diagram above.  
  
the main objectives of wp1 âdevelopment of new precursorsâ were the improvement of production of cfs from different precursors (such as from stabilized pan fibers, ligninocellulosic precursors, a novel polymeric structure and pan nanofibers produced by electrospinning), the development of a resin delivery system to enable the carbon fibrecf precursors and their hybrids to be delivered to the extrusion equipment and the characterization of cfs produced by different precursors.   
  
in addition, the major objectives of wp2 âsynthesis and functionalisation of carbon fibres â compositesâ included the manufacturing of fibre reinforced composites via the eco-production technique, the modification of a resin delivery unit as appropriate to enable the carbon fibre filaments to be coated by the specified resin system and enhancement of properties of carbon fibres produced.   
  
the wp3 âcharacterization of materials and mechanical testingâ aimed to the characterization of physical properties of new fibers developed, the study of microstructure of the new carbon fibers produced and to probe the mechanical properties o  
f the new fibers & composites developed.   
  
while, the wp4 âmaterials development (supply), hybrid materialsâ purposed to develop a novel mechano-electro-spinning apparatus to the production of highly oriented precursor preforms, to develop techniques to stabilise the molecular alignment of the precursor preforms during the heat-treatment regimens and to develop novel surface multi-functionalisation technique for new fibres based on active-screen plasma. the main objective of this workpackagewp4 is to prepare advanced flexible supercapacitors based on carbon nanofibers and innovative techniques.  
the wp5 âdedicated modelling of process and propertiesâ aimed to develop new combination of models and computational simulation method procedure based on finite element method (fem) in order to study the mechanical interaction (shearing and fracture) between fibers / matrix and to develop an integrated technique in order to study the fibre-resin interface structure and bonding and to validate the micro-mechamicsmechanics model.  
  
furthermore, the major objectives of wp6 âqualification, standardization, production of (certified) reference materialsâ were to dissiminate the fibralspec project message to international experts and encourage them to apply project results to their work and explore the new markets.  
  
in wp7 âmanufacture of proof of conceptâ, the proof of concept products were excellent examples of the broad range of products that can potentially be created by the newly developed carbon fibres. it was performed the proof of concept 1 âhigh technology â small scale: supercapacitorsâ and the proof of concept 2 âmedium technology â large scale: rapid deployment secure emergency shelter (rdses)â. the aim of proof of concept was to take an existing concept ârapid deployment secure emergency shelterfibreglassâ (rdses-fg) designed and developed applying traditional composite manufacturing techniques and, by employing the use of carbon fibre to be reduced the unit mass while at the same time increasing rigidity, durability and end user usability, resulting in rapid deployment secure emergency shelter carbon fibre (rdses-cf). this proof of concept will can be extended to using glass and carbon hybrid structures that use the appropriate materials in the appropriate situations.  
  
the most important objectives of wp8 ârecyclingâ were to specify strategies, at the start of the precursor development programme, to enable the carbon fibre waste (waste is defined as: precursor waste, carbon fibre production waste and recovered carbon fibre waste), to develop processing routes for the carbon waste generated in the fibralspec project, including those recovered from composites manufactured by the consortium using the fibralspec carbon fibres and to evaluate the thermo-oxidative and mechanical properties of the carbon fibre composites manufactured from waste and recycled fibralspec carbon fibres.  
  
the wp9 âlife cycle assessmentâ aimed to quantify the green credentials of the reuse/recycling strategies via lca and lcc analyses. the objective of the âdissemination, exploitation and standardizationâ work package (wp10) was to build consensus and raise awareness around the achievements of the whole project and how to implement them. the dissemination activities helped in achieving a critical mass of stakeholders aware of the upcoming breakthrough innovations, challenges and goals of the project. the exploitation component ensured that there was a credible plan for taking the ideas and concepts into the market and commercializing them eventually. from the fibralspec project perspective, the successful dissemination strategy aimed:  
  
(a) to extract and give the main messages or key implications from the project results,   
(b) to identify methods to raise awareness of the project,   
(c) to encourage communication between key players regarding the results of the project and   
(d) to develop ways so that deliver the fibralspec project message to the targeted audience and encourage them to apply project results to their work and explore the new markets  
  
finally, it is referred the main general objectives of wp11 âmanagementâ. the project had been managed according to well defined procedures aimed at the delivery of quality project results to the commission within time and budget. the main objectives were (a) to coordinate and conduct the project according to the work plan, (b) to identify and confirm deliverables and milestones, (c) to analyze the risks associated with project execution and to take corresponding mitigation actions, (d) to ensure efficient and high-quality communication between the partners, (e) to ensure a smooth transfer of information (e.g. reports) to and from the commission and (f) to distribute the financial support paid by the commission among the partners.  
  
project results:  
work package 1: development of new precursors  
  
a. improvement of production of cfs from renewable resources  
to date, the most common precursor used to produce carbon fibre is polyacrylonitrile (pan). when investigating the cost of producing carbon fibre, it becomes clear that more than 50% of the cost is related to the production of the precursor. the remaining cost is distributed as such: 15% to the oxidation process, 23% to the carbonization process, and the remaining to sizing and spooling. the key to reduce the production cost of carbon fibre is the use of an alternative precursor.   
within fibralspec the production of cfs from renewable resources was extensively analyzed. specifically, stabilization and carbonization process of rayon-based fibers and the experimental procedures to optimize the production process to a certain extent were conducted. also the processing conditions were optimized for efficient production. the work clearly showed that by using appropriate processing conditions, it is possible to produce good quality carbon fibers from rayon precursor.   
another biopolymer with high carbon content allowing high carbon yields at low costs is lignin. if lignin is compared to pan as precursor for carbon fibre, the ability to reduce the cost of manufacturing is by more than 50%. lignin is a natural waste byproduct of the paper industry and biorefineries, which is readily available in enormous amounts and due to this very inexpensive. lignin is also a sustainable, renewable resource. the use of lignin offers significant cost saving potential in the production of carbon fibre. lignin makes it possible to produce a carbon fibre based on renewable resources.   
one of the major drawback of lignin-based cfs is the poor mechanical properties comparing to pan-based cfs. blends with improved properties were fabricated via compounding lignin with suitable polymers. despite the fact that blending process is a potential method for producing durable and spinnable materials, polar lignin powder appears low compatibility/miscibility in a nonpolar polymer matrix. for this reason, a variety on lignin modifications were conducted (acid treatment, alkylation, and esterification) in order to examine the miscibility with polymers like polyethylene oxide et al.   
another work dealing with lignin as cfs precursor is the synthesis of pan-lignin copolymers. during copolymerization processes of lignin with specific monomers, a new renewable polymeric material is possible to be synthesized and applied as a candidate of cfs precursor. the study of bamboo as cfs precursor and carbonization/graphitization of cotton waste fibers was conducted as well.   
  
b. lignin chemical stabilization   
în the research field of cf production melt spinning of lignin has been an issue. moreover, the potential of cf production and applicability of softwood lignin is under question in respect of the low mechanical properties of the resulting cfs. in our study, modification and polymer blending were conducted and optimized together with incorporation of softwood lignin in the chemical stabilization process. that showed the effectiveness of sulfonation on the introduction of thermosetting property of hdpe (hybrid high-density polyethylene)/skl (softwood kraft lignin) fibers via chemical crosslinking, using various analytical tools. according to the literature, no studies have been reported related to the aforementioned chemical stabilization process. this alternative route, suggested in our study, could provide a novel approach for the investigation of incorporation of softwood lignin resources, which currently remain unused, to added-value high prospect products.  
during our research, stabilization of melt-spun hdpe-skl fibers was examined involving physical (thermal) and chemical methods. using a 3x3 factorial experimental design, sulfonation temperature and time effect on the fiber properties were examined, focusing on the thermal stability of the final product. the optimum result in terms of morphology and crosslinking index was obtained by a two-step sulfonation process.  
after the sulfonation, the mass of the abovementioned fiber remained relatively stable (only about 35% mass loss) when the temperature was raised up to 900 â°c and remained there for some time. carbonization of the hdpe/skl fiber was successful, producing a cf, which was sustained intact even at 900 â°c. regarding the morphology and the characteristics of the produced cf, they demonstrate significantly better physical properties than the precursor fibers and they are relative to similar results from recent literature.  
concerning the current state of the art in this field, the present study demonstrates advantages of paramount importance. the simpler way of chemical stabilization outbalances the previous attempts on exclusively thermal stabilization of fibers, which is both much more energy and time consuming. in addition, the amount of chemical reagents used to reach this outcome is minimal. this work succeeded in investigating the possible ways of manufacturing cfs using common low cost commercial polymers and raw first materials, such as lignin. further exploitation of this studyâs results can lead towards the enhancement of such production and the increase of applications in everyday life. these significant achievements show the manner in which the production of green cfs can be scaled up and overly improved.  
  
c. thermal treatment (stabilization, carbonization) of cfs precursors   
the thermal treatment and characterization of lignin (and ligninâs blends) as candidate precursors for cfs was investigated in detail. fibres originated from lignin blends were studied by thermal oxidative treatment in various rates in order to evaluate their thermal stability. additionally, mechanical properties prior and after thermal treatment of lignin-based fibres were measured.   
the results demonstrated that cfs are feasible to be produced using novel fibralspec precursors. the carbonization process can be further performed at elevated temperatures (> 1200 oc) and if graphitization (> 2000oc) could be achieved then promising cfs could be produced using the proposed method. additionally, the application of tension during carbonization could limit the shrinkage phenomena. the serious most serious issue that should be tackled is the weight losses during high temperature process; these have to be controlled in order to improve the yield of the process. this aim could be achieved by dehydration of the fibres prior to their thermal oxidative treatment, preferably by chemical means (e.g. by their impregnation with flame retardants, which enhance thermal stability and prevent the evolution of volatile by-products by blocking the primary hydroxyl groups).   
in case of thermal treatment for lignin, the modification by acid resulted in more homogeneous and more thermally stable material. moreover, the alkylation by bromododecane increased the initial decomposition temperature and the esterification by phthalic anhydrate showed the wider decomposition region (about 300 oc), but otherwise caused decrease of the thermal stability of lignin. in the end, the esterification by maleic anhydride leaded to narrow enhancement of thermal stability.   
d. continuous stabilization line (for oxidation treatment of cfs precursors)  
one of the main tasks was on improving the most crucial step of the process, i.e. the oxidative stabilization. the stabilization and carbonization processes of pan-based fibers and the experimental procedures to optimize the production process to a certain extent have investigated. the specific objectives were to evaluate the stabilization stage with respect to mechanical properties of the pan-based fibers. the aim of the study was to establish the rules for designing oxidative thermal treatment that led to the optimization of fibre stabilization, using the results of their isothermal treatment. the optimal pan fibre stabilization conditions were achieved when the effect of the decomposition reactions was minimized. a simple experimental protocol, which can be followed and applied not only in laboratory but also in larger scale, has been provided, after the examination of optimization of pan oxidative stabilization and subsequent pyrolysis. ntua has designed and established a pilot unit (figure 2) in order to produce stabilized lignin fibre at high volume. automatic control system of stabilization line can optimize the aforementioned procedure by changing a variety of parameters.  
  
within fibralpsec the sequence of cf production process from green fibres as described below was followed:   
  
stabilization. during stabilization of the fibre; dehydration, rearrangement, formation of carbonyl groups, evolution of carbon monoxide and carbon dioxide, and formation of carbonaceous residue occur alongside the thermal scission of glycosidic bonds between the glycopyranose units of the cellulose. the scission produces oxygenated compounds that lead to maximum loss of the mass. tars and coke residue are the main volatiles gaseous products formed during the thermal degradation. by adding proper chemical such as impregnants or flame-retardants, one can moderate the stabilization mechanism by lowering the temperature range and subsequently improving the carbon yield by reducing the burning loss as well as having better stabilized fibres for further processing (carbonization and graphitization).   
carbonization. this step includes heating of the fibres between 500â°c to 1500â°c (high temperature processing). during this step, non-carbon atoms are removed from the atomic structure. at this stage, all chemical processes are completed, structural transformations take place, the coke becomes enriched with carbon, and the fibre properties alter. the resulting fibres have bonded crystalline structures with better alignment and orientation. as the temperature rises, the structure of the residue becomes more complicated, in spite of simplification of the elemental composition.   
graphitization. it is the final stage of the production process (higher temperature processing). most of the process is energy intensive and is responsible for the high cost of cfs. depending on the fields of the final application, either carbonized or graphitized cf can be the end product. the main phenomena occur are structural transformations and simultaneous changes in the properties of the fibres. the most important processes during this stage are: further aromatization of carbon atoms, growth of crystallite size and graphite like ribbons, and perfection of the orientation of the ribbons along the fibre axis.   
  
e. screening study  
selection criteria have been proposed to evaluate cellulose, lignin and other natural polymers as precursors for manufacturing carbon fibres. a template to enable short-listing of potential precursors, and the subsequent development of a technical document, was issued to the wp1 partners. the key attributes implied in the template were as follows:   
(a) precursor related costs â the availability (scarcity) and cost of the precursor, cost associated with any secondary/tertiary chemicals and processing; recycling of solvents; separation of precursors from by-products; purification of precursors; disposal of primary waste; pre-preparation costs prior to fibre formation (drying, etc); flushing/cleaning materials cost; disposal of secondary waste.   
(b) preform and fibre production costs - local ventilation and extraction (lev); costs associated with the primary and secondary processing equipment for producing preforms and fibres. this will be based on the specialist equipment being developed / used by the relevant partners including items required for melt-extrusion, wet-spinning, dry-spinning and mechano-electro-spinning.   
(c) energy and utility costs for preform production, stabilisation, carbonisation and graphitisation â it is envisaged that the equipment costs in this category was covered by item (b) above. the current category is linked to the cost of power (electricity, gas, etc) and utility (water, inert gas, compressed air, etc).   
(d) properties of the fibralspec carbon fibres â this is proposed as the primary criterion for evaluating the fit-for-purpose of the carbon fibres produced in the project.   
(e) environmental impact â this is not covered explicitly during screening as it is the subject of wps 8 and 9.   
  
f. development of a novel synthetic polymer as possible new cf precursor  
one of the main objectives was to develop a novel synthetic polymer as possible new cf precursor. in order to improve different aspects of cf production, a different approach was applied: developing novel tailored pan block copolymers (as a means for improving quality of cf). initial research results demonstrated that it is possible to synthesize acrylonitrile-based copolymers with specified structure using activator generated by electron transfer atom transfer radical polymerization (aget-atrp) polymerization method in microemulsion system. the new polymer was designed with a structure containing aromatic structures. this material is thought to be a good candidate for cfs since it demonstrates large carbon yield after pyrolysis (increasing the process efficiency) and could possible modified to cfs with enhanced properties. according to the synthetic process, at first, the synthesis of the proper monomer is performed taking into account that it should have enhanced reactivity (react in mild conditions) and absence of solvents during polymerization. it is mentioned that special attention is given to the physicochemical properties of the fabricated polymer (especially its thermo mechanical behaviour), in order to propose suitable production methods. after the fabrication of the new fiber precursors, the experimental parameters for their modification into cfs were investigated and corresponding protocols were developed related with the pyrolysis as well as stabilization processes. the benefits of the aforementioned study are considered to be: a. fulfillment of monomer production expectations, b. new cost-effective material for utilization in cfs industry.  
  
g. fiber spinning  
melt spinning process has been proven by far that is better spinning process than dry spinning in several aspects. melt spinning apparatus is easily handled, easily cleaned, can run with a small amount of material in the form of powder or pellets (>5g) and achieved continuous production of lignin-based fiber. on the other hand, dry spinning did not manage to produce an acceptable length of continuous fiber. moreover, the organic solvents used in spinning dope solutions are toxic and dangerous for human health.   
continuous production using commercial polymers was achieved via melt spinning. it is observed that unmodified lignin forms agglomerates in the extruder when it is mixed with commercial polymers, resulting on larger fiber diameters due to decreased compatibility between materials. this problem was solved by modifying lignin and resulted on smaller fiber diameters and better compatibility with commercial polymers, such as polylactic acid (pla) and polypropylene (pp).   
finally, it was noticed that chemical modifications of lignin increased the molecular weight, enhanced compound miscibility and improved the produced materialâs thermal stability.   
  
work package 2: synthesis and functionalization of carbon fibres â composites  
  
for today, carbon-based materials have received much attention for their many potential applications. the carbon fibers are very strong, stiff, and lightweight, enabling the carbon materials to deliver improved performance in several applications such as aerospace, sports, automotive, wind energy, oil and gas, infrastructure, defense, and semiconductors. however, the use of carbon fibers in cost-sensitive, high-volume industrial applications is limited because of their relatively high costs. however, its production is expected to increase because of its widespread use in high-volume industrial applications; therefore, the methods used for manufacturing carbon fibers and carbon fiber-reinforced composites and their structures and characteristics need to be investigated.   
one of the most actual tasks of all researchers interested in carbon fibers and polymer based composites reinforced by carbon fibers is directed changing of their structure, physical and chemical properties for enhancing of their service characteristics and opening of new functional possibilities of their using.   
carbon fibers have received much attention lately for their many potential applications in different matrix materials owing to their properties, processability, and recyclability. however, raw cfs need to be treated and/or sized as part of the manufacturing process. designing of suitable surface-treatment method is a requisite to ensure that the high strength of the cfs is maintained during handling and composite manufacture. the surface treatment or sizing method is also equally important to ensure the formation of cf-matrix interface. in the process of creation of polymer based composite materials the special attention should be paid to the study and control of the interactions at inter phase boundaries. it is very important for the composite materials on ...

# FIBRALSPEC

Project Acronym: FIBRALSPEC

programme & topic: FP7-NMP NMP.2013.2.1-1

Most frequent returning words in objectives:

* ('carbon', 66)
* ('production', 37)
* ('lignin', 32)
* ('fibres', 31)
* ('fibre', 30)
* ('properties', 27)
* ('process', 26)
* ('project', 25)
* ('fibers', 23)
* ('precursor', 21)
* ('composites', 20)
* ('stabilization', 20)
* ('cost', 19)
* ('precursors', 19)
* ('materials', 18)
* ('thermal', 17)
* ('chemical', 16)
* ('fibralspec', 15)
* ('fiber', 14)
* ('treatment', 14)
* ('waste', 14)
* ('applications', 13)
* ('work', 12)
* ('results', 12)

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in accordance with the overall concept presented above, the project has had the following aims and objectives:  
â¢ the improvement of production of carbon fibres from "green" precursors such as lignin and renewable resources and control of precursor oxidation treatment   
â¢ the manufacturing of fibre reinforced composites via eco friendly-production techniques  
â¢ the functionalization of cfs mainly focused on cost reduction, mechanical and chemical property improvement  
â¢ the use of the reinforced composites in different applications, such as: flexible supercapacitors and rapid deployment secure emergency shelters  
â¢ as for recycling and used of recycled cfs, new techniques have been used to provide commercially-relevant products that are manufactured from waste carbon fibres  
â¢ the application of lca to quantify the green credentials of the reuse and recycling strategies from the start -precursor development-, till the carbon fibre waste.  
â¢ testing of laminates and prepregs production based on the new developed carbon fibres followed by manufacturing of laminates/coupons and high-performance filament wound tubes are also foreseen  
â¢ mathematical modeling has been conducted so as to determine properties of cfs and composites, together with cost modeling  
  
fibralspec project is divided into 11 major major workpackages work packages (wps) (figure 1). these constitute the main work breakdown structure of the project, gathering together the major groups of activities to be carried out. the overall structure is shown in the figure 1diagram above.  
  
the main objectives of wp1 âdevelopment of new precursorsâ were the improvement of production of cfs from different precursors (such as from stabilized pan fibers, ligninocellulosic precursors, a novel polymeric structure and pan nanofibers produced by electrospinning), the development of a resin delivery system to enable the carbon fibrecf precursors and their hybrids to be delivered to the extrusion equipment and the characterization of cfs produced by different precursors.   
  
in addition, the major objectives of wp2 âsynthesis and functionalisation of carbon fibres â compositesâ included the manufacturing of fibre reinforced composites via the eco-production technique, the modification of a resin delivery unit as appropriate to enable the carbon fibre filaments to be coated by the specified resin system and enhancement of properties of carbon fibres produced.   
  
the wp3 âcharacterization of materials and mechanical testingâ aimed to the characterization of physical properties of new fibers developed, the study of microstructure of the new carbon fibers produced and to probe the mechanical properties o  
f the new fibers & composites developed.   
  
while, the wp4 âmaterials development (supply), hybrid materialsâ purposed to develop a novel mechano-electro-spinning apparatus to the production of highly oriented precursor preforms, to develop techniques to stabilise the molecular alignment of the precursor preforms during the heat-treatment regimens and to develop novel surface multi-functionalisation technique for new fibres based on active-screen plasma. the main objective of this workpackagewp4 is to prepare advanced flexible supercapacitors based on carbon nanofibers and innovative techniques.  
the wp5 âdedicated modelling of process and propertiesâ aimed to develop new combination of models and computational simulation method procedure based on finite element method (fem) in order to study the mechanical interaction (shearing and fracture) between fibers / matrix and to develop an integrated technique in order to study the fibre-resin interface structure and bonding and to validate the micro-mechamicsmechanics model.  
  
furthermore, the major objectives of wp6 âqualification, standardization, production of (certified) reference materialsâ were to dissiminate the fibralspec project message to international experts and encourage them to apply project results to their work and explore the new markets.  
  
in wp7 âmanufacture of proof of conceptâ, the proof of concept products were excellent examples of the broad range of products that can potentially be created by the newly developed carbon fibres. it was performed the proof of concept 1 âhigh technology â small scale: supercapacitorsâ and the proof of concept 2 âmedium technology â large scale: rapid deployment secure emergency shelter (rdses)â. the aim of proof of concept was to take an existing concept ârapid deployment secure emergency shelterfibreglassâ (rdses-fg) designed and developed applying traditional composite manufacturing techniques and, by employing the use of carbon fibre to be reduced the unit mass while at the same time increasing rigidity, durability and end user usability, resulting in rapid deployment secure emergency shelter carbon fibre (rdses-cf). this proof of concept will can be extended to using glass and carbon hybrid structures that use the appropriate materials in the appropriate situations.  
  
the most important objectives of wp8 ârecyclingâ were to specify strategies, at the start of the precursor development programme, to enable the carbon fibre waste (waste is defined as: precursor waste, carbon fibre production waste and recovered carbon fibre waste), to develop processing routes for the carbon waste generated in the fibralspec project, including those recovered from composites manufactured by the consortium using the fibralspec carbon fibres and to evaluate the thermo-oxidative and mechanical properties of the carbon fibre composites manufactured from waste and recycled fibralspec carbon fibres.  
  
the wp9 âlife cycle assessmentâ aimed to quantify the green credentials of the reuse/recycling strategies via lca and lcc analyses. the objective of the âdissemination, exploitation and standardizationâ work package (wp10) was to build consensus and raise awareness around the achievements of the whole project and how to implement them. the dissemination activities helped in achieving a critical mass of stakeholders aware of the upcoming breakthrough innovations, challenges and goals of the project. the exploitation component ensured that there was a credible plan for taking the ideas and concepts into the market and commercializing them eventually. from the fibralspec project perspective, the successful dissemination strategy aimed:  
  
(a) to extract and give the main messages or key implications from the project results,   
(b) to identify methods to raise awareness of the project,   
(c) to encourage communication between key players regarding the results of the project and   
(d) to develop ways so that deliver the fibralspec project message to the targeted audience and encourage them to apply project results to their work and explore the new markets  
  
finally, it is referred the main general objectives of wp11 âmanagementâ. the project had been managed according to well defined procedures aimed at the delivery of quality project results to the commission within time and budget. the main objectives were (a) to coordinate and conduct the project according to the work plan, (b) to identify and confirm deliverables and milestones, (c) to analyze the risks associated with project execution and to take corresponding mitigation actions, (d) to ensure efficient and high-quality communication between the partners, (e) to ensure a smooth transfer of information (e.g. reports) to and from the commission and (f) to distribute the financial support paid by the commission among the partners.  
  
project results:  
work package 1: development of new precursors  
  
a. improvement of production of cfs from renewable resources  
to date, the most common precursor used to produce carbon fibre is polyacrylonitrile (pan). when investigating the cost of producing carbon fibre, it becomes clear that more than 50% of the cost is related to the production of the precursor. the remaining cost is distributed as such: 15% to the oxidation process, 23% to the carbonization process, and the remaining to sizing and spooling. the key to reduce the production cost of carbon fibre is the use of an alternative precursor.   
within fibralspec the production of cfs from renewable resources was extensively analyzed. specifically, stabilization and carbonization process of rayon-based fibers and the experimental procedures to optimize the production process to a certain extent were conducted. also the processing conditions were optimized for efficient production. the work clearly showed that by using appropriate processing conditions, it is possible to produce good quality carbon fibers from rayon precursor.   
another biopolymer with high carbon content allowing high carbon yields at low costs is lignin. if lignin is compared to pan as precursor for carbon fibre, the ability to reduce the cost of manufacturing is by more than 50%. lignin is a natural waste byproduct of the paper industry and biorefineries, which is readily available in enormous amounts and due to this very inexpensive. lignin is also a sustainable, renewable resource. the use of lignin offers significant cost saving potential in the production of carbon fibre. lignin makes it possible to produce a carbon fibre based on renewable resources.   
one of the major drawback of lignin-based cfs is the poor mechanical properties comparing to pan-based cfs. blends with improved properties were fabricated via compounding lignin with suitable polymers. despite the fact that blending process is a potential method for producing durable and spinnable materials, polar lignin powder appears low compatibility/miscibility in a nonpolar polymer matrix. for this reason, a variety on lignin modifications were conducted (acid treatment, alkylation, and esterification) in order to examine the miscibility with polymers like polyethylene oxide et al.   
another work dealing with lignin as cfs precursor is the synthesis of pan-lignin copolymers. during copolymerization processes of lignin with specific monomers, a new renewable polymeric material is possible to be synthesized and applied as a candidate of cfs precursor. the study of bamboo as cfs precursor and carbonization/graphitization of cotton waste fibers was conducted as well.   
  
b. lignin chemical stabilization   
în the research field of cf production melt spinning of lignin has been an issue. moreover, the potential of cf production and applicability of softwood lignin is under question in respect of the low mechanical properties of the resulting cfs. in our study, modification and polymer blending were conducted and optimized together with incorporation of softwood lignin in the chemical stabilization process. that showed the effectiveness of sulfonation on the introduction of thermosetting property of hdpe (hybrid high-density polyethylene)/skl (softwood kraft lignin) fibers via chemical crosslinking, using various analytical tools. according to the literature, no studies have been reported related to the aforementioned chemical stabilization process. this alternative route, suggested in our study, could provide a novel approach for the investigation of incorporation of softwood lignin resources, which currently remain unused, to added-value high prospect products.  
during our research, stabilization of melt-spun hdpe-skl fibers was examined involving physical (thermal) and chemical methods. using a 3x3 factorial experimental design, sulfonation temperature and time effect on the fiber properties were examined, focusing on the thermal stability of the final product. the optimum result in terms of morphology and crosslinking index was obtained by a two-step sulfonation process.  
after the sulfonation, the mass of the abovementioned fiber remained relatively stable (only about 35% mass loss) when the temperature was raised up to 900 â°c and remained there for some time. carbonization of the hdpe/skl fiber was successful, producing a cf, which was sustained intact even at 900 â°c. regarding the morphology and the characteristics of the produced cf, they demonstrate significantly better physical properties than the precursor fibers and they are relative to similar results from recent literature.  
concerning the current state of the art in this field, the present study demonstrates advantages of paramount importance. the simpler way of chemical stabilization outbalances the previous attempts on exclusively thermal stabilization of fibers, which is both much more energy and time consuming. in addition, the amount of chemical reagents used to reach this outcome is minimal. this work succeeded in investigating the possible ways of manufacturing cfs using common low cost commercial polymers and raw first materials, such as lignin. further exploitation of this studyâs results can lead towards the enhancement of such production and the increase of applications in everyday life. these significant achievements show the manner in which the production of green cfs can be scaled up and overly improved.  
  
c. thermal treatment (stabilization, carbonization) of cfs precursors   
the thermal treatment and characterization of lignin (and ligninâs blends) as candidate precursors for cfs was investigated in detail. fibres originated from lignin blends were studied by thermal oxidative treatment in various rates in order to evaluate their thermal stability. additionally, mechanical properties prior and after thermal treatment of lignin-based fibres were measured.   
the results demonstrated that cfs are feasible to be produced using novel fibralspec precursors. the carbonization process can be further performed at elevated temperatures (> 1200 oc) and if graphitization (> 2000oc) could be achieved then promising cfs could be produced using the proposed method. additionally, the application of tension during carbonization could limit the shrinkage phenomena. the serious most serious issue that should be tackled is the weight losses during high temperature process; these have to be controlled in order to improve the yield of the process. this aim could be achieved by dehydration of the fibres prior to their thermal oxidative treatment, preferably by chemical means (e.g. by their impregnation with flame retardants, which enhance thermal stability and prevent the evolution of volatile by-products by blocking the primary hydroxyl groups).   
in case of thermal treatment for lignin, the modification by acid resulted in more homogeneous and more thermally stable material. moreover, the alkylation by bromododecane increased the initial decomposition temperature and the esterification by phthalic anhydrate showed the wider decomposition region (about 300 oc), but otherwise caused decrease of the thermal stability of lignin. in the end, the esterification by maleic anhydride leaded to narrow enhancement of thermal stability.   
d. continuous stabilization line (for oxidation treatment of cfs precursors)  
one of the main tasks was on improving the most crucial step of the process, i.e. the oxidative stabilization. the stabilization and carbonization processes of pan-based fibers and the experimental procedures to optimize the production process to a certain extent have investigated. the specific objectives were to evaluate the stabilization stage with respect to mechanical properties of the pan-based fibers. the aim of the study was to establish the rules for designing oxidative thermal treatment that led to the optimization of fibre stabilization, using the results of their isothermal treatment. the optimal pan fibre stabilization conditions were achieved when the effect of the decomposition reactions was minimized. a simple experimental protocol, which can be followed and applied not only in laboratory but also in larger scale, has been provided, after the examination of optimization of pan oxidative stabilization and subsequent pyrolysis. ntua has designed and established a pilot unit (figure 2) in order to produce stabilized lignin fibre at high volume. automatic control system of stabilization line can optimize the aforementioned procedure by changing a variety of parameters.  
  
within fibralpsec the sequence of cf production process from green fibres as described below was followed:   
  
stabilization. during stabilization of the fibre; dehydration, rearrangement, formation of carbonyl groups, evolution of carbon monoxide and carbon dioxide, and formation of carbonaceous residue occur alongside the thermal scission of glycosidic bonds between the glycopyranose units of the cellulose. the scission produces oxygenated compounds that lead to maximum loss of the mass. tars and coke residue are the main volatiles gaseous products formed during the thermal degradation. by adding proper chemical such as impregnants or flame-retardants, one can moderate the stabilization mechanism by lowering the temperature range and subsequently improving the carbon yield by reducing the burning loss as well as having better stabilized fibres for further processing (carbonization and graphitization).   
carbonization. this step includes heating of the fibres between 500â°c to 1500â°c (high temperature processing). during this step, non-carbon atoms are removed from the atomic structure. at this stage, all chemical processes are completed, structural transformations take place, the coke becomes enriched with carbon, and the fibre properties alter. the resulting fibres have bonded crystalline structures with better alignment and orientation. as the temperature rises, the structure of the residue becomes more complicated, in spite of simplification of the elemental composition.   
graphitization. it is the final stage of the production process (higher temperature processing). most of the process is energy intensive and is responsible for the high cost of cfs. depending on the fields of the final application, either carbonized or graphitized cf can be the end product. the main phenomena occur are structural transformations and simultaneous changes in the properties of the fibres. the most important processes during this stage are: further aromatization of carbon atoms, growth of crystallite size and graphite like ribbons, and perfection of the orientation of the ribbons along the fibre axis.   
  
e. screening study  
selection criteria have been proposed to evaluate cellulose, lignin and other natural polymers as precursors for manufacturing carbon fibres. a template to enable short-listing of potential precursors, and the subsequent development of a technical document, was issued to the wp1 partners. the key attributes implied in the template were as follows:   
(a) precursor related costs â the availability (scarcity) and cost of the precursor, cost associated with any secondary/tertiary chemicals and processing; recycling of solvents; separation of precursors from by-products; purification of precursors; disposal of primary waste; pre-preparation costs prior to fibre formation (drying, etc); flushing/cleaning materials cost; disposal of secondary waste.   
(b) preform and fibre production costs - local ventilation and extraction (lev); costs associated with the primary and secondary processing equipment for producing preforms and fibres. this will be based on the specialist equipment being developed / used by the relevant partners including items required for melt-extrusion, wet-spinning, dry-spinning and mechano-electro-spinning.   
(c) energy and utility costs for preform production, stabilisation, carbonisation and graphitisation â it is envisaged that the equipment costs in this category was covered by item (b) above. the current category is linked to the cost of power (electricity, gas, etc) and utility (water, inert gas, compressed air, etc).   
(d) properties of the fibralspec carbon fibres â this is proposed as the primary criterion for evaluating the fit-for-purpose of the carbon fibres produced in the project.   
(e) environmental impact â this is not covered explicitly during screening as it is the subject of wps 8 and 9.   
  
f. development of a novel synthetic polymer as possible new cf precursor  
one of the main objectives was to develop a novel synthetic polymer as possible new cf precursor. in order to improve different aspects of cf production, a different approach was applied: developing novel tailored pan block copolymers (as a means for improving quality of cf). initial research results demonstrated that it is possible to synthesize acrylonitrile-based copolymers with specified structure using activator generated by electron transfer atom transfer radical polymerization (aget-atrp) polymerization method in microemulsion system. the new polymer was designed with a structure containing aromatic structures. this material is thought to be a good candidate for cfs since it demonstrates large carbon yield after pyrolysis (increasing the process efficiency) and could possible modified to cfs with enhanced properties. according to the synthetic process, at first, the synthesis of the proper monomer is performed taking into account that it should have enhanced reactivity (react in mild conditions) and absence of solvents during polymerization. it is mentioned that special attention is given to the physicochemical properties of the fabricated polymer (especially its thermo mechanical behaviour), in order to propose suitable production methods. after the fabrication of the new fiber precursors, the experimental parameters for their modification into cfs were investigated and corresponding protocols were developed related with the pyrolysis as well as stabilization processes. the benefits of the aforementioned study are considered to be: a. fulfillment of monomer production expectations, b. new cost-effective material for utilization in cfs industry.  
  
g. fiber spinning  
melt spinning process has been proven by far that is better spinning process than dry spinning in several aspects. melt spinning apparatus is easily handled, easily cleaned, can run with a small amount of material in the form of powder or pellets (>5g) and achieved continuous production of lignin-based fiber. on the other hand, dry spinning did not manage to produce an acceptable length of continuous fiber. moreover, the organic solvents used in spinning dope solutions are toxic and dangerous for human health.   
continuous production using commercial polymers was achieved via melt spinning. it is observed that unmodified lignin forms agglomerates in the extruder when it is mixed with commercial polymers, resulting on larger fiber diameters due to decreased compatibility between materials. this problem was solved by modifying lignin and resulted on smaller fiber diameters and better compatibility with commercial polymers, such as polylactic acid (pla) and polypropylene (pp).   
finally, it was noticed that chemical modifications of lignin increased the molecular weight, enhanced compound miscibility and improved the produced materialâs thermal stability.   
  
work package 2: synthesis and functionalization of carbon fibres â composites  
  
for today, carbon-based materials have received much attention for their many potential applications. the carbon fibers are very strong, stiff, and lightweight, enabling the carbon materials to deliver improved performance in several applications such as aerospace, sports, automotive, wind energy, oil and gas, infrastructure, defense, and semiconductors. however, the use of carbon fibers in cost-sensitive, high-volume industrial applications is limited because of their relatively high costs. however, its production is expected to increase because of its widespread use in high-volume industrial applications; therefore, the methods used for manufacturing carbon fibers and carbon fiber-reinforced composites and their structures and characteristics need to be investigated.   
one of the most actual tasks of all researchers interested in carbon fibers and polymer based composites reinforced by carbon fibers is directed changing of their structure, physical and chemical properties for enhancing of their service characteristics and opening of new functional possibilities of their using.   
carbon fibers have received much attention lately for their many potential applications in different matrix materials owing to their properties, processability, and recyclability. however, raw cfs need to be treated and/or sized as part of the manufacturing process. designing of suitable surface-treatment method is a requisite to ensure that the high strength of the cfs is maintained during handling and composite manufacture. the surface treatment or sizing method is also equally important to ensure the formation of cf-matrix interface. in the process of creation of polymer based composite materials the special attention should be paid to the study and control of the interactions at inter phase boundaries. it is very important for the composite materials on ...

# FLY-BAG2

Project Acronym: FLY-BAG2

programme & topic: FP7-TRANSPORT AAT.2012.5.1-1.

Most frequent returning words in objectives:

* ('fly-bag', 55)
* ('blast', 54)
* ('aircraft', 47)
* ('cargo', 38)
* ('device', 24)
* ('cabin', 24)
* ('project', 23)
* ('container', 21)
* ('hold', 20)
* ('resistant', 18)
* ('mitigation', 18)
* ('explosion', 17)
* ('textile', 17)
* ('developed', 16)
* ('development', 16)
* ('luggage', 15)
* ('body', 15)
* ('pallet', 15)
* ('board', 14)
* ('protection', 14)
* ('structure', 14)
* ('lightweight', 14)
* ('case', 13)
* ('containment', 13)

executive summary:  
aviation is constantly under threat. terrorists have proven that they might be able to circumvent security scans both by carrying explosive devices on board themselves and by sending parcel bombs via mail or hidden in luggage. currently available security scans are necessary, but cannot guarantee a 100% detection rate: complementary passive countermeasures are needed to protect aircraft, crew and passengers in case on board explosions.  
  
up to date, all efforts are focused on preventing an explosive device from getting on board, but no back-up protection exists in case pre-emptive security fails: the only way to overcome the circumvention of the active security measures by terrorists is by providing complementary passive protective measures, both for the cargo hold and passenger cabin, able to attenuate the effects of an explosion during flight in order to reduce the structural damage and maximise the chance of survival of the aircraft and of people on board.  
  
the eu research project fly bag2 has developed a technology that could allow planes in the future to survive a lockerbie-sized explosion. made of highly resistant fabric, the simply looking fly bag2 comes in two variants â for cabin use and cargo holds. the fly-bag2 project was funded by the european commission and ran by a consortium of institutes and specialist companies from greece, spain, italy, germany, sweden and the netherlands.  
  
the idea is to protect the aircraft using a bag, a system made of textile that can be folded inside a headlocker under normal circumstances and if a suspicious device is found, it can be placed inside the fly bag and placed to the least risk bomb location (lrbl) â a reinforced part of the aircraft where an explosion would cause minimal damage.  
  
while the cabin-version requires the crew to act before the explosion, the cargo hold type of the fly bag â coming in two versions for narrow-body and wide body aircraft, provides a ready passive countermeasure against a lockerbie-inspired plot.  
  
in the case of wide-body aircraft, fly-bag system made of multi-layered textile is fitted inside the standard aluminium containers that are used for loading luggage. the second type is suitable for narrow-body aircraft, where usually the aluminium containers are not used. so the idea is to create a bag that is installed inside the cargo hold of the narrow body aircraft and like an internal screen protects the fuselage against the blast.  
  
fundamental to the design of the bag is a combination of fabrics which have high strength and impact and heat resistance. the fabrics include aramid, which is used in ballistic body armour. key to the concept is that the lining is flexible and this adds to its resilience when containing the explosive force and any fragments produced. this helps to ensure that the fly-bag acts as a membrane rather than as a rigid-walled container which might shatter on impact.  
the fly-bag, which lines an aircraftâs luggage hold with multiple layers of novel fabrics and composites, was tested under increasing explosive charges on disused planes at cotswolds airport, near cirencester, on november 2014 and july 2015. the bomb-proof lining successfully contained blasts in a series of controlled explosions in the luggage hold of a boeing 747 and an airbus 321.  
using this technology, the tests have demonstrated that a planeâs luggage hold may be able to contain the force of an explosion should a device concealed within a passengerâs luggage be detonated during a flight. this would mitigate damage to the plane and help keep passengers safe. after the tests, explosives were placed in the aircraft without the lining to show the damage that could be caused.  
  
the technology could either be something that becomes compulsory for all airlines to use if the law was changed or could be used by airlines responding to particular threats.  
  
project context and objectives:  
project context  
despite stringent security checks commercial airliners remain a favourite target of terrorists. foiling these suicidal plots has always centred on intercepting suspicious packages and passengers within the airport before passengers board their plane. if a bomb evades security staff at this juncture then only a failure to detonate will avert disaster and mass casualties.   
  
the dramatic event represented by the plane crash of the russian airliner, brought down over the sinai peninsula on october 2015, is the latest terrorist atrocity involving commercial aircraft. at present, all efforts are focused on preventing an explosive device from getting on board, but no back-up protection exists in case pre-emptive security fails: the only way to overcome current limitations of active scanning methods is by providing complementary passive protective structures, both for the cargo hold and passenger cabin, able to attenuate the effects of an in-flight explosion and guaranteeing survival of aircraft and passengers.  
  
the idea of reinforced air cargo containers is not entirely new: the research efforts performed in the 1990s in the usa and uk led to the development of several prototypes of reinforced containers, named hardened unit load devices (hulds). different huld concepts were tested by the federal aviation administration between 1997 and 1998. hulds never gained market acceptance due to their common drawbacks, namely cost, weight, bulkiness and insufficient resistance to damage during everyday loading/unloading operations. moreover, they were only designed for wide-body aircraft: narrow-bodies are in general not always compatible with ulds; even when compatibility exists, airlines often prefer to load luggage in bulk due to cost and logistic problems.  
  
concerning the aircraft passenger compartment, aviation regulations mandates that a least risk bomb location (lrbl) be identified on each aircraft; this area represents a designated location where a bomb or other explosive device could be placed to best protect integrity of the structure and flight-critical systems from damage in the case of detonation. some products have been proposed to provide a measure of attenuation of the explosive force in the event of detonation; these solutions, based on phase-changing materials or thick reinforced plates, are generally unacceptably bulky or are not suitable to be used in an aircraft passenger compartment.  
  
the fly-bag2 research project - âadvanced technologies for bombproof cargo containers and blast containment units for the retrofitting of passenger airplanesâ (grant agreement no. acp7-ga-2008-213577 â starting date: 2012-08-01 end date: 2015-09-30), co-founded by the european commission, has developed solutions for mitigating the effects of a possible explosion of explosive devices concealed on board aircraft, an event that most of the times caused catastrophic results.  
  
the fly-bag2 approach is based on the development of retrofitting solutions for the mitigation of on board explosions. direct strengthening of the airplane structure would clearly result in thicker skins and a weight penalty; moreover, the related costs could not be justified in the majority of the commercial routes. instead, the fly-bag2 blast mitigation solution has been developed to be easily implemented on existing aircraft without the need to modify their main structures.  
  
as the name implies, fly-bag2 builds upon the success of a previous (2011) fp7 research project fly-bag, âblastworthy textile-based luggage containers for aviation safetyâ acp7-ga-2008-213577â which developed and demonstrated a blast-resistant textile-based luggage container for narrow-body passenger airplanes. the knowledge gathered in the previous project was exploited to develop new devices for both cabin and cargo environments, enlarging the experimental validation of the new concepts including full scale tests on dismissed aircraft, which were not performed in the previous fly-bag project.  
  
objectives  
the improvement of the security in the aircraft was the primarily objective of fly-bag2, which addressed the threat of on board explosions in the cabin or in the cargo hold of passenger and cargo airplanes. fly-bag2 research work addressed the application of innovative and cost effective solutions, to reduce the possibility of an aircraft to suffer from an action of any kind which could compromise its security and improve survivability if the action takes place.  
  
direct strengthening of the airplane structure clearly result in thicker skins and a weight penalty; moreover, the related costs are not justified in the majority of the commercial routes. instead, the fly-bag2 blast mitigation and retrofitting solutions were developed to be easily implemented on existing aircraft without the need to modify their main structures.  
  
fly-bag2 was focused on developing two different devices for the protection of cabin and cargo compartment environments, the fly-bag2 cabin version and the fly-bag2 cargo version, both based on breakthrough high performance technical textiles and lightweight energy absorbing composite elements.  
  
the fly-bag2 cabin solution was developed to address to a precise requirement set forth by aviation authorities: on october 2008, faa in the usa issued far 25.795 (design for security) for new airplane design, implemented by easa in august 2010 with the 9th amendment to cs 25, in particular the revised version of 25.795, stating that:  
  
an aeroplane with a certificated passenger seating capacity of more than 60 persons or a maximum take-off weight of over 45 500 kg (100,000 lbs) must comply with the following:   
(1) least risk bomb location (lrbl). except for aeroplanes intended to be used solely for the transport of cargo, an aeroplane must be designed with a designated location where a bomb or other explosive device could be placed to best protect integrity of the structure and flight-critical systems from damage in the case of detonation. [â¦]  
  
the faa advisory circular 25.795-6, also foresees that:   
â[â¦] when a suspect item is found in the cabin of an airplane in flight, measures to minimize its effect include the following: (...); minimizing the loss of integrity of the structure or systems; using explosive containment devices. [â¦]  
âtraditionally, the lrbl was chosen where there was intrinsic structural reinforcement. however, the applicant may take other measures to meet the intent of the rule. an example would be a containment system [â¦]â  
  
the lrbl regulation represents a challenge for aircraft manufacturers; a solution for containment systems specifically designed for addressing the above regulations would be extremely useful to further reduce the effects of on-board explosions. fly-bag developed a compact blast resistant flexible and foldable container based on a multi-layered high-performance textile structure. the opening is provided by a high-strength zip closure. the container is flexible and foldable, in order to be easily stored in a small volume (for instance in an overhead locker) when not in use.  
  
the fly-bag2 cargo solution was conceived to tackle the menace posed by explosive devices concealed in cargo shipments. it was based on developing a uld-like device, sharing all geometrical dimensions with currently used standard ulds, in order to ensure maximum compatibility and reusability. a robust but lightweight composite floor is used to accommodate shipped goods, while a multi-layered textile cover hanging on a lightweight frame tubular structure is used for the external walls, instead of aluminium of the standard uld, yielding blast protection. as for the cabin version, the closure of the bag is performed through a high resistant zip, which allows a quick and easy opening and closing of the uld and, at the same time, blast resistant and gas tightness. an important objective was the development of blast resistant design, characterised by same dimensions and freight volume as a standard uld, with also similar weight and price to the customer. in particular, ld3 ake and pmc/p6p pallet were the reference standards for the fly-bag2 wide-body cargo solutions, as it is the most widely used for luggage. thus, the containers developed within the project were âake compatibleâ and âpmc compatibleâ as far as dimensions and handling are concerned; ake and pmc/p6p current products were used as a benchmark for the containerâs cost and weight.  
  
more in details, the following objectives were fully achieved at the end of the project:  
1. development of solutions for the effective protection of wide body aircraft: we already demonstrated in the previous fly-bag project that the textile-based technology, for the protection of narrow body aircraft, can be effectively applied also for solutions tailored for wide body aircraft. the approach followed in fly-bag2 was based on the development of blast-proof unit load devices (ulds), able to offer both the standard function of providing safe and airworthy transport of cargo and baggage on containerized aircraft and the fire and blast resistant function;  
2. development of solutions addressing the least risk bomb location (lrbl), common to both narrow-body and wide body aircraft;  
3. development of blast-resistant solutions characterized by low-weight, low-cost and ready to be installed on board of aircraft, without any long certification process;  
4. validation of the fly-bag2 blast-mitigation capabilities, through full scale blast tests on dismissed aircraft: it was within the objective of fly-bag2 to perform blast tests on dismissed aircraft, with and without blast mitigation technologies, in order to proof their effective performance and the effects of the (mitigated) blast on the surrounding structures. the availability of such test results allowed the validation of the numerical methods, developed in the project, and brought a insight knowledge about materials performance in such extreme conditions.  
  
summarising, the main objective of fly-bag2 project is to provide passive security measures for the mitigation and containment of on board blast and for the cost effective retrofitting of aircraft travelling on critical routes. fly-bag2 solutions have been developed to achieve the highest degree of protection to aircraft and passengers by counteracting threats posed by both explosive devices smuggled inside the passenger cabin and by bombs concealed inside uld, thanks to flexible and lightweight textile-based materials, lightweight composites and high resistant zip closures.  
  
project results:  
the scientific & technological (s&t) results achieved during the fly-bag project are following summarized:  
  
1. cabin device: blast mitigation envelope for containment of suspected explosive devices found in a cabin of an aircraft during flight, addressing the least risk bomb location (lrbl) directive;  
2. ake version (uld) â fly-bag2 blast mitigation kit for standard air container uld (type ld3 ake and similar) to be installed inside an existing uld container in order to make it blast resistant, without modification to the structural characteristics of the uld itself;  
3. pmc pallet version (uld): blast mitigation unit for standard pmc/p6p pallet (uld) used to load luggage, freight and mail on wide body aircraft, without modification to the structural characteristics of the pmc/p6p pallet (uld). the unit can be tied down with a standard pallet net, just as any other standard palletized cargo;  
4. cargo hold liner for narrow body aircraft: development of a textile-based, lightweight, and blast resistant cargo hold liner, for the protection of narrow-body aircraft (a320 family);  
5. composite frame for ake and pmc pallet kit (ulds): development of a composite lightweight frame for fly-bag2 ake and pmc pallet kit, to support the textile blast resistant bag;  
6. composite floor and side sandwich panels: development of composite lightweight panels for fly-bag2 cargo hold device (for ake and cargo hold liner version), to enhance shrapnel mitigation of more vulnerable locations within the cargo hold;  
7. blast resistant zip closure: development of a high strength zip, to be used in the cargo and cabin blast containment unit, characterized by easiness of use, high strength and possibility to control venting through the zip teeth;  
8. fire-resistant abrasion-resistant, and gas-tight coated textiles and coating application method; knowledge of suited coating formulations and their application on high strength materials as well as for the selection of commercially available additives;  
9. ake version (uld) - extra-light uld construction: certified ake version according to aviation authorities requirement made with new extra light materials for bottom, walls and profiles;  
10. blast mitigation composite hardened side panels (as reinforcement of the lrbl): a hardened composite panel to replace the conventional interior cabin liner. it is meant to provide protection to the airframe in case the cabin flybag2 fails to contain the blast from an improvised explosive device (ied). the panel concept could replace the whole cabin liner and provide blast and potentially fire protection to the whole structure;  
11. material numerical models and blast simulation methods: textile and composite materials numerical models validated by means of the experimental tests carried out. numerical methodology, implemented in simulation tools, to model the explosion phenomenon. the methodology was validated on the basis of the blast tests;  
12. manufacturing methods of fabric envelope: development and set-up of methods for manufacturing in a suitable and cost effective way the blast resistant multi-layered envelopes for the fly-bag2 blast containment units;  
13. blast test results: knowledge related to the blast resistance of the components of the construction (fabrics, zip) and the assembly;  
14. impact test methodology and tests results: an experimental methodology for the analysis of the impact behaviour of textile and composite materials was developed within the project;  
15. dynamic test results on fabrics: availability of results of experimental tests during high-speed mechanical tests carried out for establishing the dynamic behaviour of fabrics used for developing the fly-bag2 blast resistance fabric envelope;  
16. fire test results: experiences in different test procedures and evaluations referring also to automotive and aviation standardisation for selected and investigated high strength materials;  
17. least risk blast location procedures: development of specific procedures for cabin and flight crew members adapted to use of the fly-bag2 container;  
18. certification of fly-bag2 cargo hold liner for narrow body aircraft: approval of fly-bag2 cargo hold liner installation for a320 aircraft family.  
  
cabin device  
one of the most important s&t project result has been the development of an innovative envelope for containment of suspected explosive devices found in a cabin of an aircraft during flight, addressing the lrbl directive.  
  
in the milliseconds immediately following the explosion, a strong impulse load ("shock holing") of high intensity, highly localized and of short duration is generated and is transmitted to the structures in contact with the charge. in the milliseconds following the explosion, the expansion of gases generates a pressure wave that expands substantially uniformly distributed, as a sphere.   
the passage of the pressure wave through the air, it causes the compression and imparts an acceleration to the particles of air in a radial direction, with respect to the point of detonation. the arrival of the shock wave corresponds to a peak value of pressure (overpressure), which decreases exponentially until it reaches again the value of the atmospheric pressure.  
  
if the explosion occurs in a closed volume, as a container, a second effect is added to the first one: this is due by the multiple reflections of the pressure wave on the walls of the container. the queues of each peak are added together, giving an effect of accumulation of total pressure, higher than the ambient pressure and known as quasi-static (quasi static pressure, qsp), which can last several seconds. the maximum pressure associated with this second phase is usually much less than that associated with the impulse, but given its long duration can also cause extensive damage.  
  
fly-bag2 cabin device is intended to be used in a situation when an explosive object or device, for example found on board an aircraft, during the flight, has to be isolated as soon as possible. first of all, it is important to highlight that the device has been designed and manufactured such to be placed at an area called as âleast risk bomb locationâ (lrbl) such to limit the effects generated by the explosion (if any) and such to contain the fragments of the device projected by the explosion, in the best possible manner.  
  
substantially the blast mitigation device is composed by the following components:  
1. an inner bag suitable to contain the bomb threat, entirely made of textile;  
2. an outer bag, entirely made of textile;  
3. zips for closing the open ends of both the containers or bags;  
4. longitudinal straps, similar to the safety belts currently used in the aeronautical field.  
the two bags are two textile cylinders that in the assembled condition are placed concentrically, one inside the other one, with the open mouths facing the same side.  
the two bags have been designed to have the smallest possible number of structural seams. the inner and the outer bag can be made in a similar manner, only having different dimensions or, preferably, the inner bag can have a different textile structure than the outer one.  
  
from the blast tests conducted in fly-bag2 project, it has been found that the use of a gas permeable material is optimal. the gas permeability of the chamber inside the bag is able to discharge a part of the power and amplitude of the shock wave (initial pressure peak) before reaching the first breaking of the inner bag.  
the outer bag, has a higher diameter and volume capacity, therefore is stressed (in case of an explosion) with a time delay to follow the peak of the explosive energy.   
  
in an alternative configuration, in order to mitigate the âshock-holingâ phenomenon (that can cause the device to be perforated in the point where the explosive is placed) a third component called âshieldâ can be added, in addition to the two inner bag and outer bag. such shield, as the inner and outer bag, has a flexible tubular shape and can be made of the same material used for the other components. the âshieldâ is made in a manner similar to what described above, with the difference that it has no zipper or zip fastener.  
  
concerning the material, the inner bag is composed by a multi-layered fabric made of para-aramid fabric. it has still to be noted that the material is flame-resistant, both by its inherent characteristic and also by means of a flame-resistant coating that may be applied later. concerning the outer bag, the material can be the same of the inner bag (para-aramid); however, an alternative can be the use of hm-pp (âhigh modulus polypropyleneâ).   
  
from the blast tests conducted in the project, it results that the overpressure peak is the one that risks to cause the most dangerous damages to the aircraft. therefore, the technical characteristics of this blast containment system, even if allowing the exploded gas to escape from the device, slow down the escape, therefore limiting the intensity of the pressure wave deriving from explosion.  
  
the blast mitigation device can be folded and stored in a storage compartment, inside the aircraft approved to be fire resistant according to aviation rules. to this end, deformability and the lightweight are important characteristics of the device.  
  
the main characteristics of the cabin device are following summarized:  
1. innovative product not available in the market up to now;  
2. lightweight;  
3. flexible;  
4. relatively cheap;  
5. when not used it is folded and kept in an overhead locker; this way it is not wasting space on-board and it does not scare passengers;  
6. despite competitors exist, none of these products has up to now met market success from airlines. multiple reasons can be identified for the scarce diffusion of such anti-bomb protection devices: all of them share the same disadvantages, as they are in general heavy, bulky and moreover expensive. in addition, their potential impact on passengers must be considered: flying is more psychologically demanding then most other transportation means and the explicit presence of a blast disposal container on board can give rise to panic.  
  
the cabin bag is being protected. an italian patent was applied. the patent title is: âdispositivo di attenuazione di uno scoppio e relativo metodo di fabbricazioneâ and was applied on september 29, 2014 (ref. no. i0 50842, it mi2014a001695 â international patent classification ipc: inv. f42d5/045 b65d90/32). the applicant is dâappolonia s.p.a.   
the patent was evaluated positively with regard to novelty, inventive step and industrial applicability. the partners decided to extend the italian patent as a patent cooperation treaty (ptc). the international patent âblast mitigation device and manufacturing method thereofâ was filed by dâappolonia on september 28, 2015 (ptc/ep2015/001914).  
  
ake version (uld) â fly-bag2 blast mitigation kit for uld  
another important project result is the development of a mitigation system for different geometries of ulds, able to contain the effects of explosion in the cargo area in case of charge concealed in the luggage.  
  
the idea was to develop a blast mitigation kit for standard ulds (ld3 ake and similar). the fly-bag2 kit can be installed inside any existing uld container. the installation of the fly-bag2 kit is done without any modification of the uld, in order not to endanger the certification of the uld. the kit does not have any physical connection to the uld itself. the textile structure is sustained by an internal lightweight composite frame. a composite sandwich floor is added inside the structure. the fly-bag2 kit has basically the inner dimensions of the ake and is provided by a zip, for loading and unloading luggage operations.  
  
with exception of the zip closure, a seamless design was developed for the textile blast mitigation kit; based on the data measured during the project, this leads to maximum strength for the high tenacity fabrics chosen for the prototype. the teeth of the zip are directly mounted on the multilayer fabric. such a seamless construction can be obtained by using a customized manufacturing process, developed for fly-bag2 production.  
  
the kit makes blast resistant a standard uld. the price/weight ratio is competitive against hardened uld. patent has been granted covering the main european countries.  
  
pmc pallet version (uld)  
this project result consists in the development of a version of fly-bag suitable for pmc/p6p cargo uld, to make the uld blast resistant. the solution could be combined with a fire barrier concept which is currently being commercialized for the transportation of lithium batteries.  
  
the design of the fly-bag for pmc/p6p pallet started analysing the standard procedures used for loading the euro-pallet on the pmc/p6p cargo pallet. in this case, the fly-bag device is composed by the following elements:  
1. a fly-bag âbaseâ (called also âbottom assyâ), similar to that used for thermal covers. the base can be fully opened and connected to the lateral sides of the fly-bag cover;  
2. a fly-bag âcoverâ, similar to that used for thermal covers. the âcoverâ can be fully opened thanks to the use of four vertical zips placed on the lateral sides;  
3. latitudinal straps at the bottom, all around the textile, to tighten the top to the base;  
4. a âstabilizer rackâ, to avoid collapse of the structure.  
  
on the market, no solutions are available to make a pmc pallet blast proof. patent has been granted covering the main european countries.  
  
cargo hold liner for narrow body aircraft  
this project result is very similar to the precious one, with the difference that is a blast mitigation envelope tailored for the cargo holds of narrow body aircraft. the innovative potential of this concept stays in the possibility to protect against on board explosions the cargo area of narrow body aircraft, where no hardened uld could be used.  
  
fly-bag cargo hold liner device is based on full containment of the quasi-static pressure (qsp), generated by the blast by deformation of the flexible composite layers making the container. local reinforcement to withstand shock loading at floor and critical interfaces is achieved using rigid composite materials. the access is allowed by an innovative use of zip system which is designed to withstand the quasi-static pressure generated by the blast. the zip system also provides an easy opening and closing of the container during loading and unloading operations at the airport. in case non-hazardous goods bigger than the container itself have to be loaded inside the cargo hold of the plane, the container itself is designed to be foldable allowing to be easily removed and stored.  
  
fly-bag2 blast containment unit has been developed to be installed inside a narrow body aircraft, namely the airbus a320 family.  
  
the fly-bag2 system foresees the same routine of operations as bulk loading, with the difference that luggage is loaded inside the container, which is already mounted in the hold. the only additional step required is opening the fly-bag2 container to load luggage in it. all equipment remains the same, with of course the addition of the fly-bag2.  
  
patent has been granted covering the main european countries.  
  
composite frame for ake and pmc pallet kit (uld):  
the composite frame for the ake pallet is a lightweight structure to keep the fly-bag2 cargo unit used for wide body aircraft (both ake container and pmc pallet) in its intended shape. the frame is one component of the full ake and pmc pallet unit containment unit.  
  
composite floor and side sandwich panels  
composite panels designed for protection from explosion exist, but they are usually developed to offer protection from debris ejected by a distant detonation in free air: in that case, the shockwave can expand in a free volume far from the panels, and only a minimal fraction of it impacts directly on the panel.  
  
sandwich panels have stiff outer skins, coupled to a lightweight core which can be made crushable for energy absorption. glass or aramid are the materials of choice for skins in high performance panels, while for the core various possibilities were investigated.  
  
the composite panels are used for the floor of ake and cargo hold liner units. such panels are characterized by a structure which is designed to withstand the shock holing forces generated by the blast event and to distribute such impulse onto the internal surface of the textile container over a larger area. the composite panels cover entirely the floor of the internal surface of the textile container and the lateral walls, where required, to provide additional protection to rear critical structures. the composite lateral elements were designed to be foldable to allow the entire container to be quickly unfolded and removed.   
  
the innovation is the composition of how many layers and how to space them together, alongside with what materials to use in the composite floor to make it resistant against the blast along with having it as lightweight as possible. the floor is a crucial part of the whole fly-bag2 cargo unit to protect the airframe from damage in case of a blast scenario.  
  
the floor and the sloping side panels consists of only one piec,e avoiding weak point in the intersection among the panels. the floor is made by a foldable corner of the same materials as the rest of the floor. special hinges were developed for this purpose.  
  
blast resistant zip closure  
the connection between two fabrics forms a discontinuity in the textile surface; this is potentially a weak point in a blast resistant application: in order to avoid this, the connection must possess at least the same tensile strength as the weaker adjoining fabric. a zip is the most immediate and easiest way to connect two pieces of fabric: high strength zips exist having resistance to lateral pull high enough to be considered as a practical closure for flybag2.  
  
zip closure was chosen, both for cargo and cabin applications. the choice was guided by three characteristics:  
1. easiness of use;  
2. existence of high-resistant zips;  
3. possibility of controlled venting ...

# FIRE-RESIST

Project Acronym: FIRE-RESIST

programme & topic: FP7-NMP NMP-2009-2.5-1

Most frequent returning words in objectives:

* ('fire', 55)
* ('thermal', 25)
* ('materials', 24)
* ('fibre', 24)
* ('polymer', 23)
* ('composites', 22)
* ('matrix', 17)
* ('developed', 17)
* ('properties', 17)
* ('figure', 17)
* ('temperature', 16)
* ('furan', 16)
* ('fibres', 16)
* ('work', 16)
* ('mmll', 16)
* ('resin', 16)
* ('material', 15)
* ('behaviour', 14)
* ('heat', 14)
* ('char', 14)
* ('resins', 14)
* ('laminates', 13)
* ('project', 12)
* ('cork', 12)

executive summary:  
the overall aim of the project is to develop novel, cost-effective, high-performance, lightweight polymer matrix composite materials with a step-change improvement in fire behaviour. fire-resist will achieve this by carefully targeted research in five key areas:  
1. multi-micro-layered structural materials that are designed to delaminate extensively when exposed to heat, thereby generating a multiplicity of internal interfaces that provide a fire barrier of exceptionally low thermal conductivity.  
2. hybrid thermoset composites that are polymeric at normal temperature, but which decompose under fire to provide highly protective ceramic char phases.  
3. high char polymer matrix composites derived from naturally occurring furan and cork.  
4. the commingling of particle-doped polymer fibres and conventional fibre reinforcements as a highly efficient means of dispersing fire retarding particles within a polymer composite.  
5. advanced multi-scale simulation of polymer matrix composites in fire through the use of a fire degradation material model in conjunction with coupled computational fluid dynamics and structural finite element analysis as a tool for research, development and design.  
  
the viability of the material solutions developed in fire-resist was proven through the development of application case prototypes for the aeronautic, rail and maritime industries. this work was supported by a suite of tests against the relevant industry standards and supported by cfd, fds and fea modelling. lca and lcc was performed to demonstrate the long-term viability of introducing the developed materials to the marketplace against the operational criteria for each industry application. the project delivered three full-scale demonstrators as proof-of-application and these were showcased at jec 2015 in paris.   
  
project context and objectives:  
the greater use of polymer matrix composite materials would be highly desirable. their low weight, along with their inherent resistance to corrosion and fatigue, enables more fuel efficient and sustainable transport structures. however, for many applications, the biggest factor currently preventing the more widespread use of light high-performance polymer matrix composites is their poor fire performance. this is due to the organic matrices, which first soften on heating, causing a loss of mechanical properties and then, at higher temperatures, decompose. decomposition results in the production of smoke and toxic or flammable decomposition products. these products are not only hazardous in terms of lack of visibility and toxicity; they can also burn, releasing heat, which can lead to flame spread and exacerbate the fire. furthermore, loaded composite structures often collapse in a fire within a period of minutes, depending on the magnitude of the load and heat flux.  
  
the overall aim of the project is to develop novel, cost-effective, high-performance, lightweight polymer matrix composite materials with a step-change improvement in fire behaviour. fire-resist will achieve this by carefully targeted research in five key areas:  
  
1. multi-micro-layered structural materials that are designed to delaminate extensively when exposed to heat, thereby generating a multiplicity of internal interfaces that provide a fire barrier of exceptionally low thermal conductivity.  
  
2. hybrid thermoset composites that are polymeric at normal temperature, but which decompose under fire to provide highly protective ceramic char phases.  
  
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5. advanced multi-scale simulation of polymer matrix composites in fire through the use of a fire degradation material model in conjunction with coupled computational fluid dynamics and structural finite element analysis as a tool for research, development and design.  
  
project results:  
  
3.1 wp1  
multi-micro-layered laminates have been developed as an effective fire barrier that significantly prolongs the heat transfer into an underlying substrate and hence decelerates its temperature increase which delays mechanical softening as well as onset of thermal degradation processes. the concept behind this is the transformation of the polymeric constituent of multi-micro-layered laminates (mmll) into a gaseous product because of pyrolysis when exposed to fire. due to layered structure these volatile gases are trapped within the laminates causing extensive delamination which consequently forms an effective insulation shield.   
  
during the initial phase the focus was laid on the development of these novel material types. suitable materials, i.e. metal foils and polymeric resin, and several manufacturing techniques have been tried out and eventually optimised. various mmll architectures have been developed in order to investigate the influence of basic characteristics such as foil thickness and layer number onto the fire behaviour of these mmll when used as a surface fire protection material.   
  
the main work involved the experimental characterisation of the newly-developed materials. besides microstructural analysis and extensive investigation of the polymer resin used in the laminates, the thermal transport properties of the mmll were determined in a simple thermal step-change experiment over a wide temperature range. measurements from room temperature up to 250â°c of the mmll thermal conductivity revealed a continuous reduction with increasing temperatures which is associated with the resin softening and onset of thermal degradation. the thermal conductivity of a decomposed and expanded laminate was found to be reduced to 9% of its room temperature value which proves essential for the formation of the laminateâs fire protection effect.   
  
standard cone calorimeter tests were carried out to evaluate the fire performance of specimens featuring mmll as a surface protection measure in comparison to unprotected substrates. the great improvements achieved are exemplarily shown in figure 2 below for two different types of substrate materials. in general, laminated substrates exhibit much increased ignition times which are caused by the much slower heating up rate leading to a delay in the onset of substrate decomposition. for the glare substrate peak hrr and thr are not greatly influenced which is in contrast to the mahre value. in this case the mahre is reduced by 50% which is due to the fact that burning consumption of the sample occurs over much longer time period which reduces the risk of fire spread in real case scenarios. for the test of entirely combustible materials cfrp substrates have been used and an even greater improvement in the fire reaction properties of samples featuring mmll was observed. besides the huge delay in ignition, hrr, peak hrr and thr are significantly reduced. unprotected samples experience a complete consumption of their polymeric constituents whereas mmll featuring specimens have higher residual mass. this is associated with the overall lower temperatures reached within the substrate due to the insulation effect of the mmll which leads to suppressed decomposition.   
  
fire-structural test have been carried to evaluate the laminates influence on samples simultaneously exposed to heat as well as mechanical load. it is shown that failure times in tests carried out under tensile and compressive conditions are greatly improved because of the introduction of mmll. the mmll insulation effect causes a much slower temperature increase of the substrate in comparison to an unprotected specimen which means it prolongs the time period until the onset of mechanical strength loss occurs, consequently leading to extended failure times and longer safe escape times in real fire scenarios. figure 3 shows time-to-failure curves for a metal and a combustible substrate, respectively. similar to the cone calorimeter results, in case of combustible substrates (cfrp) a suppression of the extensive on-going sample degradation at prolonged heating times can be achieved due to the application of the laminates onto the sample surfaces which changed the decomposition characteristics and consequently the failure behaviour in favour of extended failure.   
  
to increase the applicability of the newly-developed mmll, modified laminates have been developed which can be employed in applications posing the risk of severe fire conditions. non-melting metal foils have been introduced as a laminate top layer in order to withstand temperatures well above 1000â°c. fire exposure tests verified the superior behaviour of the modified laminates in comparison to the basic mmll design. titanium and stainless steel top layers form a resistive barrier towards the impinging flame. in comparison, basic mmll experience destructive behaviour due to successive melting of individual foils as well as ablation which increases the higher the heat flux is. hence, modified mmll pose an additional advantage over the already improved fire behaviour of structures that feature basic mmll. the temperature rise of the substrate is inhibited even further due to the withstanding of the non-melting top layer. figure 4 pictures the temperature reduction achieved at a certain time during the fire exposure test in comparison to an unprotected sample.   
  
an explicit finite difference method was successfully developed in order to simulate the temperature development within specimens comprised of multi-micro-layered laminates bonded to a substrate that is exposed to one-sided heat flux.   
  
3.2 wp2  
  
the aim of wp2 was to develop improved fire reaction behaviour in high-performance fibre reinforced polymer composites through modification of the high temperature decomposition mechanism of the matrix phase. the fire performance of composites can be significantly improved by increasing the proportion of the matrix resin that transforms to solid char rather than volatiles. char formation is beneficial because it results in lower heat release and if enough is formed, there can be sufficient char phase to hold together the fibres and provide a basic level of high temperature structural integrity. the aim was to promote char formation by using âhybrid thermosetsâ. these are resins which, at high temperatures, transform to ceramic or partially ceramic phases. the target is to achieve char yields of 60% or higher. a further advantage of promoting char formation ahead of volatile production is a reduction in the level of toxic emissions.  
  
this work package aimed to examine several hybrid thermoset systems. resins which have inherently good char-forming properties were included, such as polysiloxanes, cyanate esters and polybenzoxazines, furan resins and modified epoxies. furthermore, the addition of ceramic char-promoting particles to the resins will be investigated. these different polymers will be combined with carbon or glass fibre reinforcements to produce high performance lightweight composite materials.  
  
before laminate fabrication, it was necessary to characterise the chemo-rheology of the cure processes in the materials systems identified. this was carried out using experimental techniques including differential scanning calorimetry (dsc) and rheometry. these measurements characterised the reactions that take place both during cure and at higher temperatures in order to determine viscosity changes and phase changes such as gelation and vitrification processes as a function of resin composition and cure schedule. thermo-gravimetric analysis (tga) measurements also gave an early indication of high temperature decomposition and the transformation to ceramic phases. the results obtained in this wp provided the information needed for laminate fabrication.   
  
matlab program uicomfire\_50\_1\_2, developed at the centre of composite materials engineering (ccme), university of newcastle, allows predictions of thermal response of composite laminates in fire. program comfire was initially developed in 1994 for predictions of thermal resistance of thick gfrp laminates when exposed (with one of its two faces) to hydrocarbon fire only, based on the one-dimensional (1d) model) using finite difference (fd) numerical analysis approach. now the new version of the program developed in wp2 can be used to predict thermal responses of composite laminates exposed to a few different heating sources. resin systems and fibre reinforcements involved can be of different type. a database of thermal properties for the most common resins and fibres systems is embedded; the user can also input customised thermal properties.  
  
feasibility studies of producing hybrid thermoset composites at the quality and volumes required by the transport sector end-users were completed. options for both prepregging and liquid composite moulding (resin infusion, resin transfer moulding) were studied. pilot trials on industrial equipment were performed to verify the recommendations.   
  
wp2 scale up studies  
the work covered here was a collaborative activity as undertaken between cytec and project partners to identify potential fabrication routes and issues surrounding scale-up of the current structural composite technologies. the research in this task focused on taking the laboratory scale developments from cytec industrial materials uk and extending them to volume production, focussing on prepreg development. it was anticipated that the structural component in the multifunctional fire-resistant composites would be based on cytecâs commercially available chemicals, tooling, resin systems and fibres.   
for the structural composites reported here, plain weave carbon fibre fabric with an areal density of 245 g m-2 and density 1.76 g cm-3 could be used among others. a glass fibre fabric or a polyester mat could be used as separators. furan resins have been transformed into composites by means of infusion processing at larger scale facilities at cytec uk and apc company in sweden and within wp3 as industrial scale up, but being actually conceived as a link between the prototypes developed in wp3 and the final pieces that will be developed within wp6.   
  
3.3 wp3  
  
1.-objective  
to develop light high-performance fire-resisting composite materials based on high char polymer matrix resins synthesized from natural sources.   
2.-tasks  
task 3.1- high char polymer matrix (hcpm) formulations: (va-rtm, infusion, pre-pregging and cork agglomeration)   
task 3.2- pre-scaling of manufacturing processes.   
task 3.3- characterization of natural composites samples.   
task 3.4- industrial scale-up of hcpm composites from natural sources.   
  
3.-formulations, processing and characterization at pre-scaling level.  
  
3.1.- raw materials designed and developed during the project  
  
furan resins (tfc): furolite 050915-c (for va-rtm and infusion)   
 furolite 050915-a (for cork agglomeration)  
 furolite 120514 (for pre-pregging)   
  
acid catalysts (tfc): s and s+ (not p/n modified catalysts)  
 fr1 and fr2 (p/n modified catalysts)  
  
3.2.-commercial raw products used during the project  
  
flame retardants: fr cros 484 (app: ammonium polyphosphate)  
(char precursors) budit 3167 (mpp: melamine polyphosphate)  
   
other flame retardants: dmpp (dimethyl-propane phosphonate)  
 micral 932 (ath: aluminium trihydroxide)  
  
glass fibre: biaxial fabric 800 g/m2 and 1700 g/m2   
 chopped strand mat (csm) 300, 450 and 1800 g/m2.  
 roving 600 gm2.  
other natural fillers: liquid lignin and cork powder  
  
3.3.-prescaling: processing methods and characterization tests  
plenty of formulations were designed and processed by means of 5 different processing methods: i) va-rtm, ii) infusion, iii) prepregging, iv) cork agglomeration and v) vacuum curing process (see figure 5).  
samples were characterized in order to obtain mechanical, reaction to fire and fire resistance properties.  
  
  
4. results and conclusions.  
  
the main results and conclusions obtained are:  
4.1.- formulations developed  
a) furan resins developed during the project can be used for the production of high performance composites, pre-pregs and for cork agglomeration.  
b) furolite resins show good fire behavior themselves.   
c) p/n modified catalysts increase cross-linking times excessively (2-3 hours).  
d) app and mpp powder additives improve char formation.  
e) app and mpp powder additives improve fire behavior but they lead to processing problems due to their particle size (filter effect in vacuum infusion and rtm).  
f) dmpp increases cross-linking times excessively.  
g) cork powder increases excessively the viscosity of the resinous system and does not improve fire behavior.  
h) lignin liquid does not improve reaction to fire properties.  
  
4.2.- prescaling: processes and characterization  
va-rtm and infusion  
a) the optimal formulations, based on furan resin furolite 050915-c, are easily processed by means of va-rtm or infusion.  
b) the formulations show a suitable viscosity to impregnate 800 g/m2 glass fibre fabrics.   
c) the optimal formulations processed by va-rtm/infusion fulfill all the requirements for the railway sector (en 45545-2:2013) demanded by interior wall coverings and external cab housing (very strict requirements).nevertheless it does not fulfill one of the requirements demanded by the imo 2010 ftpc code for the naval sector.  
d) to fulfill this naval requirement it has been necessary to include 3 p.p.h of ath micral 932.  
e) the mechanical properties are also suitable for these applications.  
  
pre-pregging  
a) furan resin (furolite 120514) is suitable for pre-preg manufacturing.  
b) the furan composites manufactured show excellent mechanical and reaction to fire properties (similar to the phenolic ones).  
  
cork agglomeration  
a) furan resin furolite furolite 050915-a does not show enough flexibility to manufacture thin flexible cork sheets (3-5 mm).   
b) cork agglomeration with flame retarded (app: fr cros 484) furan resins is possible for thick panels (10 mm).   
c) mechanical and reaction to fire results show that their use in railway applications can be possible.  
d) some manufacturing problems: not suitable spreading of the mixture on the double belt press.   
  
microwave curing  
a) microwave curing tool, compared to conventional curing methods, improves mechanical properties in the same order that found in the bibliography (more than 10% better).   
b) fire properties are lightly better.   
c) lower curing times have been obtained  
  
coating application  
a) furan superficial aspect can be improved using decorative coatings (epoxy, polyurethane, etc).  
b) fire behaviour properties can be improved by means of intumescent coatings.   
  
4.3.- industrial scale-up  
a) furan resins and their curing agents are very corrosive due to the content of water (resin) and the acidity of the curing agent. moulds and tools need to be built in a non-corrosive material.   
b) furan resin shows short pot-life, therefore cycle times need to be really short.  
c) suitable curing and post curing cycles are necessary to achieve good properties (mechanical and reaction to fire).  
d) although some curing problems appeared during vacuum infusion, this processing method should not be rejected. the problems seem to be a sizing matter of the fibres rather than a material issue.   
e) during the furan resin handling and its curing process, the product emits gases and smell. even though the majority is water, it is recommended to use the same precautions as in other thermosetting resins (polyester, epoxy, phenolic).  
f) protective precautions must be also taken into account during machining of material because the particles emitted are usually very sharp. proper protective clothing and ventilation are recommended.  
g) the best and cheapest way to manufacture products such as sandwich panels, would be the use of a glass fibre reinforced furan pre-preg pressed into a heated tool. the investment is really high (approx. 600.000-900.000â¬) but, on a large scale production, the investment will be paid off in a fairly short time. the quality of the products would be much higher compared to hand lay-up process.   
  
  
  
the following table summarized the problems appeared during the scale-up and the solutions propose for the demonstrators manufacturing.  
  
   
5.-wp3 summary. inputs to wp6: proposed demonstrator lay out   
as a final result of the wp3, a sandwich panel lay out was proposed for the final demonstrators (wp6) regarding railway and naval sectors. the lay-out is collected in figure 7.  
depending on the final application the number and the thicknesses of internal cork cores and intermediate layers can vary (figure 8).   
these demonstrators and their properties will be described in the corresponding work package report (wp6).  
  
  
3.4 wp4  
  
the concept behind the work in wp4 â âparticle-doped polymer fibres for fire-retarded commingled compositesâ was to develop fire-optimised polymer matrix formulations based on polymers which in a next step were spun into continuous fibres and eventually commingled with conventional glass or/and carbon fibres to produce composite preforms for consolidation (figure 9). during consolidation the very short polymer flow lengths, which are characteristic of commingled fibre composite systems along with the use of sub-micron-scale particulate fillers, would provide an extremely even and efficient distribution of the fire-retarding additive throughout the composite part.   
the main emphasis during the initial part of the wp was to identify and develop suitable nanocomposite formulations for the production of polymeric fibers. the work included literature reviews as well as preparation and characterization of neat polymer nanocomposites based on three on three different types of material systems: cloisite-doped pa6 (thermoplastic); boehmite-doped pes (thermoplastic) and a particle-doped epoxy (thermosetting).  
in the work, pa6 was mixed with an organo-modified montmorillonite and pes was doped with boehmite. after a proper evaluation of the combustion behaviour combined with their capability to be spun, the best formulations were sent to sicomp for subsequent spinning and commingling activities. in the following figure, standard cone calorimeter results in terms of hrr are reported for both the used matrices. clear improvements in the combustion characteristics with the addition of nanoparticles are observed for pa6 nanocomposites. the same level of improvement was not observed for pes-nanocomposites. this is mainly explained by the already inherently excellent fire resistance of neat pes that is illustrated by the difference on the scales on the y-axis in figure 10. moreover proplast has also applied a specific characterization technique for the combustion behaviour which couples a cone calorimeter test with the measurements of the top and bottom surface temperatures.   
  
optimization work on epoxy (tgddm) and curative fibre provided by cytec was also performed. the work included preparation of materials with different contents of thermoplastic (pei) and various stoechiometric ratios. a process involving the use of solvent was implemented as problems of dissolution of the fibre in the epoxy prepolymer were experienced. a polyhedral oligomeric silsesquioxane with three silanol functions (possoh) was added to the networks, either alone or in combination with aluminium triacetylacetonate.  
the pei presence due to the curative fibre addition led to phase separation and possibly phase inversion, depending on the pei content. in the network with a pei content of 10wt%, containing the possoh without the aluminium salt, the presence of poss domains was evidenced in the pei-rich phase (figure 11). on the contrary, with the aluminium salt the possoh did not phase-separated and could be located in the epoxy matrix, where it was likely to be molecularly dispersed.  
  
a great reduction of phrr (86%) and a beneficial effect on other parameters (reduction of thr and tsr, increase of residual weight) was obtained when adding the possoh in combination with the aluminium salt, in the networks containing 10wt% of pei (figure 12). this beneficial effect was associated with a clear intumescent effect. finally, the addition of both the possoh and the aluminium salt allowed to obtain materials with high tgâs, even for off-stoichiometry networks, probably due to the enhancement of epoxy homopolymerization.  
preparation of polymeric fibres was conducted in the next stages of development. initially, single-component monofilament fibre spinning trials were carried out to investigate the potential of spinning nanoparticle-doped theromoplastic fibres. multifilament fibres, see figure 13 with the different resins were prepared once the processing parameters were determined.   
  
the melt-spun fibres were later on used to prepare glass and carbon fibre composites that underwent through characterisation (microstructural, mechanical, thermal and fire behaviour).  
  
the very innovative concept of thermosetting curative epoxy fibre (cf) was originally designed for the production of thermosetting composite materials using the commingling process. the idea was to wind together the curative fibres and the reinforcement fibres (carbon or glass fibres) to produce a preform, then inject the epoxy prepolymer in the preform and finally cure. the networks were based on the tgddm epoxy prepolymer, while the crosslinking agent was introduced in the systems by using the curative fibre ef10007 (cf), produced and provided by cytec. for fibre processing reasons a rather high content of thermoplastic additive was required in the cf. this high content caused problems in the subsequent cure since an inevitable phase separation occurred i.e. the thermoplastic and thermosetting phases are separated. a detailed study in which three different thermoplastic pei contents were considered confirmed that the lowest possible pei-content (from fibre spinning perspective) inevitably yields in an undesired phase inversion of the final composite.  
with regards to the pa6-based commingled composites, within the framework of fire-resist, good quality laminates were routinely manufactured (fibre spinning-commingling-consolidation), tested and thoroughly characterised (quality control and combustion by-products). although this nanoparticle-doped commingled composite system exhibited good properties and indications of enhanced fire reaction and flammability properties in some tests, it could not be completely confirmed that nano-particles had a significant positive influence on the fibre composite fire-behaviour. tests of production of toxic gases and small particles during the combustion of neat and nano-doped pa6-based commingled composites were conducted at 35 kw/m2 and 70 kw/m2. no significant differences were observed between the two materials. the inherently high fire retardancy of the pes could not be apparently improved by the 0.6%wt of boehmite nanoparticles.  
  
3.5 wp5  
  
multi-field simulation framework for composite structures in fire  
the objective of fire-resist wp5 was to develop and validate a novel multi-field simulation framework that could be used for virtual fire testing, i.e. for the response of polymer matrix composite materials and structures to fire. a description of the main results in each of the five tasks of wp5 is given below.  
  
task 5.1 â simulation chain development  
  
the approach that was drafted in the projectâs description of work, and later detailed in milestone ms6, is based on coupling existing open-source and commercial simulation software. these include:  
  
â¢ fire dynamics simulator (fds), which is a widely used computational fluid dynamics (cfd) tool for the simulation of fire phenomena. it is developed as an open-source project led by the national institute of standards and technology (nist). vtt technical research centre of finland is responsible for the development of the thermal radiation and condensed-phase heat transfer and pyrolysis modules of fds.  
â¢ abaqus and ansys, which are both general purpose finite element analysis (fea) software. they offer tools for modelling structures under simultaneous thermal and mechanical loads. abaqus and ansys are commercial products of dassault systã¨mes and ansys inc. respectively.  
  
in the simulation framework, fds is used to model the fire environment and the heat exposure to relevant structures, while abaqus is used for their thermal and mechanical response. thermal exposure to surfaces is extracted from the fire dynamics simulation and used as a time-dependent boundary condition in the subsequent thermal-mechanical analysis. the sequential coupling scheme is illustrated in figure 14.   
  
  
task 5.2 â implementation of cfd-fea interoperability  
  
to establish the coupling chain, an interoperability tool called fds2fem was developed and shared with the project partners in deliverable d5.1. fds2fem provides sequential and one-directional transfer of thermal boundary conditions from fds to abaqus (figure 15). it was implemented as a command-line application for linux and windows operating systems, and in a later phase of the project, extensions for ansys support were realized in co-operation with dnv-gl. a number of verification cases were created to ensure the correct implementation of numerical algorithms within the interoperability tool.  
  
task 5.3 â implementation of the material models in the cfd code  
  
much of the work in wp5 concentrated in improving the capabilities of fds and abaqus to model the thermal decomposition process in polymer matrix composites, and in creating feasible models for the new materials that were under development in other work packages of fire-resist.  
  
the work related to fds was focused on pyrolysis modelling. this included adding new capabilities to the physics sub-models, their verification and validation, and developing practical methods for the estimation of pyrolysis model parameters from small-scale laboratory experiments. a notable improvement to the fds solid phase model was the capability to handle swelling and shrinking materials. also, significant contributions were made to parameter estimation methods for creating pyrolysis models based on thermogravimetric analysis (tga), cone calorimetry and the use of direct and evolutionary algorithms (figure 16. fds pyrolysis model for the furan+glass fibre laminate of wp3: (a) results of actual and simulated tga experiment, (b) heat release rate of actual and simulated cone calorimeter experiment.figure 16).  
  
the implementation and verification of the fds material models and guidance for parameter estimation was reported in deliverable d5.2.  
  
task 5.3 â discretization and implementation of the material models in the fea software  
the work related to abaqus employed both standard and user-customizable features of the software. the models developed included i) a heat transfer analysis for the temperature distribution inside the composite, the state of pyrolysis of the polymer matrix and the oxidation of fibre reinforcements; ii) a new user defined subroutine for the internal heat generation that occurs during pyrolysis; and iii) implementing a thermal-mechanical model with a transversely isotropic material representation, and temperature and residual resin content dependent elastic constants. the thermal models (i and ii) received parameters from the same experiments as the fds pyrolysis models. parameters for the mechanical model (iii) were obtained from dynamic mechanical thermal analysis (dmta). an example of temperature dependent mechanical behaviour present in the models is shown in figure 17.  
  
the implementation and verification of the fea material models was reported in deliverable d5.3.  
relevant benchmark materials and fire-resist composites were characterized using tga, cone calorimetry and dmta to model their thermal and mechanical behaviour both at ambient conditions and during their thermal decomposition process. these material models were later employed for validation purposes of wp5 task 5.5, as well as in the modelling of the maritime demonstrator experiment of wp6.  
  
task 5.5 â validation of the simulation concept  
the performance of the simulation framework was tested in a series of validation experiments. two intermediate-scale experimental methods, the so-called mini-furnace test (sp fire 119) and a custom experiment in slightly larger scale, were employed in the work (figure 18). in both experiments, a planar composite specimen was exposed to simultaneous thermal and mechanical loading. the mini-furnace tests represented tradition ...

# ALL4REST

Project Acronym: ALL4REST

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('project', 66)
* ('textile', 23)
* ('dissemination', 22)
* ('all4rest', 20)
* ('textiles', 19)
* ('materials', 17)
* ('fabrics', 16)
* ('website', 16)
* ('developed', 15)
* ('partners', 15)
* ('comfort', 13)
* ('thermal', 13)
* ('system', 13)
* ('mattress', 13)
* ('results', 13)
* ('events', 12)
* ('fair', 11)
* ('rest', 10)
* ('activities', 10)
* ('development', 9)
* ('systems', 9)
* ('hotmelts', 9)
* ('sensors', 9)
* ('sleep', 8)

executive summary:  
  
the present project, all4rest, is focused on the development of comfort-improved rest systems, using non-obstrusive technologies that promote deeper, more restorative sleep and prevent nocturnal awakenings. the successful solutions reduce awakenings and/or reduce time to sleep after an awakening and reduce sleep onset latency. within the global comfort improvement, physical and thermal parameters have been investigated, establishing quantitative and qualitative evaluation of comfort and sleep quality system. to achieve it, use of biomaterials and research of new ones, eco-friendly technologies and processes in fabrics destined to rest allow the development of new products focused to obtain an improved rest system. specific techniques of comfort evaluation have been implemented in final products characterization and validation. in addition new high value-added end products have been developed, based on the specific properties of the novel materials and technologies used. this route of constant innovation in products and processes is essential to strengthen the european textile industry and especially the sme companies.  
  
project context and objectives:  
  
all4rest was focused on the development of comfort-improved rest systems, linking enhancement of tactile and thermal comfort given by innovative textile-based solutions with best sleep quality described by end-users. physical and thermal parameters were investigated, establishing quantitative/qualitative evaluation of comfort and sleep quality in each textile system.  
  
to achieve it, the solutions developed in all4rest have been based mainly in research on:  
- new biofibres.  
- integration of pcm (phase change material)-based thermoregulating systems.  
- new/functional hotmelts (hms).  
- heatable textiles with electroconductive inks.  
- microencapsulated scents for aromatherapy, and   
- sensoring/monitoring of body temperature/pressure.  
  
objectives:   
  
all4rest project was structured under 4 specific r&d lines:  
- research on 'green' materials and processing technologies, for development of improved comfortable resting systems. (biofibres, nanofinishing, plasma and enzymatic technologies, renewable raw materials used as hotmelts with functional properties).  
- research and development of encapsulated systems for comfort improvement. (suitable materials to develop microcapsules for thermal comfort improvement, suitable materials as scenting additives to develop scent inks for sleep quality improvement).  
- research and development of heatable/cooling textiles for thermal comfort improvement. (suitable additives to formulate electroconductive inks, heatable/cooling textile systems).  
- development of sensors into textiles to monitor the sleeping quality, and react with a heatable/cooling device included in the rest system. (measure the body movement and the room temperature to react with a heatable/cooling textile system, also developed in the project, improving the thermal comfort).  
  
during the period covered by this report (15 months, from 01/10/11 to 31/12/12) the objectives above described were covered through the following work performed according to the work program:  
  
- wp1 was focused to the development of different samples of knitted fabrics with selected biofiber-based textile materials. some fabrics and compositions were investigated and also treated with enzymatic and finishing formulations to enhance tactile performance. quantities of auxiliary chemicals and functional products for these treatments were established. general properties of the unfinished/finished fabrics were tested (washing fastness, antimicrobial properties) and some successful samples of knitted fabrics were obtained. on the other hand, functionalization and coating of mattress ticking fabrics with hotmelts was, in some cases, successful. it was concluded that flame retardant and antimicrobial additives can be added via the use of a double screw compounder. the application of the (functionalized) hotmelts on the mattress ticking substrates can easily be done with the slot-die technique at temperatures around 140 â°c. the properties of the flame retardant (fr) compound were assessed via a smouldering cigarette test and the flame test (match flame equivalent). obviously, the type of hotmelt and the coating thickness has also an influence: the thicker the coating layer, the better the ignition is suppressed. hotmelt applications were done always like a coating and some mattress ticking with flame retardant properties were obtained.  
  
- wp2 has investigated different formulations for finishing fabrics (mattress ticking) with novel-reactive phase change materials (pcm) systems with enhanced linking force between binding resins and fibers. thermal capacity of each application and sample was evaluated in order to select the best fabric substrate and the right concentration of microcapsules in the padding solution. also the influence of the presence of softener on the impregnation bath was tested. measurements and tests were done using advanced analytical techniques such as scanning electron microscope sem (the best way to observe the presence of microcapsules and preferred because we are dealing with small entities, microcapsules), differential scanning calorimetry dsc (used to measure the phase change temperatures and energy storage capacities of the pcm-loaded textiles) and thermographic camera (used to observe the thermal properties of the pcm-loaded textiles). washing resistance was also tested. within the study of scenting additives, some screen printing tests were successfully carried out adding microencapsulated fragrances, testing their washing fastness (inkjet printing of encapsulated scenting additives is not possible due to clogging of nozzles). some scenting or thermoregulating pcm-based fabrics were done.  
  
- wp3 was focused on optimizing electroconductive coatings and printings developed in the first period of all4rest, but also to study integration systems of metallic yarns on fabrics. good conductivity in inkjet printing could be performed on the basis of silver particles. sintering was investigated and can be performed to develop textile-based heating elements (by printing on pes-foil or pa-foil and its subsequent lamination on textiles). by applying a voltage of 5v temperatures up to 70â°c could be obtained. the reductive deposition of metal salts directly on textiles works well. therefore it was concluded that inkjet printing is a very flexible technique in terms of pattern design. this is an advantage that also the embroidering technique has: it was used to make a resistive heating element with stainless steel yarn on ticking fabric. the pattern design can easily be adapted to the requirements of the heating zone. embroidery has proven to be a very flexible and promising textile technology to manufacture heating elements. some heatable textile-based solutions to be integrated further into a mattress were obtained and a modellisation for heatable textiles included in a textile layered-structure was developed..  
  
- work done in wp4 allowed the design and building of a sensor system that enables the measurement of the temperature and movement of a sleeping person. different material pairings were evaluated and the best outcome was achieved with a combination of different metallic yarns. next to temperature sensors, movement sensors have been developed which can detect a movement of the sleeping person. the programming of software for storing the movement during the whole night in comparison with the time was possible. the movement and temperature sensors can be used to quantify the quality of sleep. the sensors have been developed for large-scale manufacturing. therefore a sensor principle for the movement sensor has been chosen which is based on the conventional production of the mattress. the theoretically up scaling was done for the prototype obtained in all4rest. in further projects derived from all4rest, the production chain for the mattress with integrated sensors has to be prepared taking into account the special needs of the production company.   
  
- the demonstration wp5 aims at validating the rtd work packages results. innovations developed in wp1 to wp4 of all4rest were characterized and validated by different analytical methods (including standardized tests, own methods, clinical procedures, consumer panels and surveys). it was observed that the application of finishing processes (like hotmelt coating or scenting microcapsules) was in direct relationship with a decreasing of handle/tactile performance (evaluated by kes). on the other hand, finishing with nanocompounds increases handle feeling, but also the use of biofibre-based textile materials (bamboo, chitosan or soya) when compared with a usual textile material (cotton). regarding thermal comfort, skin model (to measure ret and rct) characterization showed that the application of a pcm-based finishing on mattress ticking samples was in direct relationship with a wide increasing of the thermal insulation when compared with reference samples. it also seems that the use of new biofibre textile materials on knitted fabrics can improve their breathable properties and their moisture management performance. with all the results obtained within tactile and thermal comfort evaluation of different all4rest samples and prototypes (including the auto-heatable textile prototypes developed in wp3 with capabilities to be continuously heated at a desired temperature), it seems that new mattresses including new pcm systems for thermoregulation effect and new nightwear cloths manufactured with bio-based textile materials could be realistic solutions, with clear possibilities to be integrated in the same rest system at industrial scale.   
  
clinical tests and consumer assessment were also carried out taking into account the experimental character of some all4rest developments and the prototyping performance of them. by this reason, clinical procedures (objective/analytical results) were restricted to test some different mattresses and the information obtained was complemented with a consumer assessment (subjective results) on the same samples. subjective information collected was also completed with a consumer survey on the main developments, materials and advantages of all all4rest solutions. objective and subjective positive sensations were assessed by potential customers to select a mattress with an internal spring system as preferred versus an internal foam system. people who slept on a spring-system based mattress said that their feeling and rest sensation was better, and polysomnographic (psg)/actigraphy (act) tests results were in the same direction. in addition, direct positive relations established by kes+consumer survey regarding improvement of tactile behaviour on knitted fabrics and direct positive relationships established by skin model+manikin/thermography+consumer survey regarding improvement of thermal behaviour on mattress ticking were also obtained.  
  
- wp6. training, dissemination and exploitation, is in progress since the very beginning as dissemination activities are considered crucial. among the different activities performed during the second period, we can point out the maintenance of the project website, the development of the project dossier, the dissemination of the project in several events and overall the final dissemination event in hostelco fair in barcelona.   
  
- wp7. project management is also in progress since the beginning of the project. among the main activities performed were the signature of the consortium agreements, the transfer of the pre-financing and mid-term funds, the organization of the consortium meetings and also the organization or conference calls for monitoring the work and a list of actions updated for the same purpose.  
  
project results:  
  
all4rest has achieved most of its objectives and technical goals for the period with relatively minor deviations. regarding wp1, it was concluded that can be possible to develop new biofibre-based cloths for nightwear with improved tactile behaviour; on the other hand, commercial available bio-based hotmelts are not widespread and only 2 bio-based polyamides (grades of uni-rez) from arizona chemicals and an experimental grade (under nda) fulfill the processing requirements; however, functionalization can be obtained through fr and antimicrobial additives can be added via the use of a double screw compounder and fire retardant coated samples were successfully developed. foreseen lamination tests were not realized because it was not required to bond fabric with foams along the project. in wp2, application of scenting products and pcms was successfully achieved on fabrics through different finishing/printing (padding, screen printing) techniques, and only inkjet printing was unsuccessful (due to clogging problems on nozzles of the printer device). in wp3 it was possible to develop heatable textile-based devices with textile techniques (e.g. embroidering and printing of electroconductive inks) and in wp4 a combination of movement/temperature sensors were developed and integrated into the same textile system (mattress). in wp5, not all the developments and technical solutions obtained in all4rest were tested with all the analytical tools (due to technical reasons: metallic wires and electric connexions on heatable or sensoring textiles, industrial size of a sample required for a specific test, etc.), but characterization of tactile/thermal improvements and its relation on objective/subjective assessment of better comfort was successfully achieved. in some cases, there was coincidence between empirical data and perception of customers. psgs/acts and consumer's assessment were found as powerful tools to validate rest products from an objective+subjective point of view.  
  
at the end of the project, all the developments and technical solutions obtained were analysed about an estimation of their industrial cost and capabilities to be manufactured at industrial level, with positive conclusions for some of them (biofiber-based knitted fabrics, new pcm-finished mattress ticking and mattresses, integration of heatable devices, textile sensorizing for clinical purposes, etc.). different technical developments have been proposed for a demo fp7-sme-2013 project (proposal all4restgo2market): a) mattresses with thermoregulation performance, b) pyjamas manufactured with biofibre-based knitted fabrics giving soft touch/better hand (also skin benefits) than conventional materials, and c) bedclothes manufactured with biofibre-based yarns looking for enhanced touch/comfort or finished with pcms.  
  
potential impact:  
  
the developed research generate high societal and market impact for the european smes, and enable major technological breakthroughs not only in the rest products market but in other sectors that could take profit of the developments such as technical textiles for cloths and automotive industry.  
  
main dissemination activities and exploitation of the results.   
  
the dissemination activities of the project have been consistent with the originally planned dissemination activities of the project proposal as well as with the dissemination action plan. the partners, as depicted in table 1 below, have used an array of mediums and tools in order to successfully disseminate the project to the relevant audience. the presentation of prototypes and other relevant technology has been available for partners and has been promoted to customers and other stakeholders. in order to raise public awareness of the proposed technology, the partners have performed pre-marketing stimulation activities such as editorials, conference papers, sales, presentation in fairs and marketing contact with potential customers internationally, through the use of trade press, trade bodies and plant suppliers, approvals bodies, consumer groups and regulatory authorities. activities include technology demonstration events, major exhibitions, stimulation events, presentations and conference papers, databases and the distribution of project promotional material.  
  
events   
  
the project was noted with overall success in relation to the participation of the partners in events. a variety of different events took place such as conferences, participation in exhibitions and fairs as well as participation in seminars. the technology of the project has been presented thoroughly and throughout these events, with the partners aiming at maximizing the visibility of the project results. the partners also participated in notable and world-renowned brokerage events. the events helped to promote the project towards targeted audiences via personal fair stands and promotional material.   
  
in relation to external conferences, the partners have participated in world-renowned conferences such as the european technology platform for the future of textiles and clothing annual conference held in march 2011 in brussels, the infoday 'ten successful stories of applied research' alcoy, march 2011, smart textiles salon in ghent (belgium) in april 2011 the fair techtextil in frankfurt may 2011, itma fair (textile machinery fair) in september 2011 in barcelona, habitat fair in valencia, september 2011, 6th european congress 'surf on the waves of innovation in coating and lamination', belgium, september 2011, on the road to a bio-based economy. belgium, october 2011, bayern innovative kooperationsforum for textile&sensorik in tegensburg (germany) october 2011, the systex conference in belgium november 2011, aachen-dresden international textile conference aditc, november 2011, textile innovative symposium and fair furth (germany) february 2012 where the sensors and the project leaflet were presented, the infoday market trends surveillance, alcoy march 2012, smart fabrics conference, miami usa march 2012, infohappenings 'hotmelts' zwijnaarde (belgium), june 2012, business convention in troyes france called citext held in june 2012 the business convention brings together every 2 years more than 300 international participants, users or suppliers of technical textiles. during these days b to b meetings are organized with participants from 8 different countries: belgium, france, germany, italy, spain, switzerland, uk and usa. symposium 'smart textiles and embroideries', bregenz (austria), september 2012, reha care fair dusseldorf (germany), hostelco fair, barcelona october 2012 where a corner of ecus booth was fully dedicated to show the project and its prototypes. a dedicated leaflet was also developed as a dossier of all the project developments and also some totems with project information. ecus customers had the opportunity to learn about the project and to know about ecus perspectives. smart medical textiles aachen (germany), november 2012, 'the use of functionalized hotmelts for different textile applications' aachen-dresden congress, november 2012, medizintechnik symposium, dresden (germany) december 2012, promotion of the project results related microcapsules through devan most important customers on bedding market. december 2012.  
  
specific mention must be made in relation to the type of audience each event was targeted, since the dissemination activities performed approached an array of interested parties, coming from different fields and areas of interest. universities and academic institutions, technology institutes and industrial partners are some examples of the type of audience the dissemination activities aimed at. specifically for industrial partner, it is notable to mention that events took place such as participation in conferences, fairs and exhibitions satisfying industry.  
  
all events had a wide geographic approach, targeting both audiences in europe and the us. the well-received reactions of these audiences demonstrate that the all4rest technology is indeed innovative in various contexts and not only related to improving the quality of the rest but also in medicine, car industry, technical textiles for hard conditions.  
  
publications   
  
publications, either in the form of press releases or as scientific papers with the intention of being published and/or in the process of being published, have played a significant role in the dissemination of the project. the project has been disseminated in various newspaper articles, both in hard copy and on the internet. many articles published concerned the distribution of the projectâs press release in notable magazines, scientific journals and industrial blogs.   
  
press releases were aimed primarily at the local audience, particularly professionals and industrial stakeholders. this medium has proved particularly useful since it has disseminated the project at large to a wide public which would not be easily identified via standardized methods of dissemination such as events and scientific conferences. all partners have maximized the potential for dissemination and visibility via the project's press release. a variety of academic, online and popular journals have published the all4rest press release.  
  
some of the articles published were:  
- article in valencia i+d website  
- article in kmm-vin newsletter (knowledge-based materials)  
- aitex magazine  
- internet melliand newsletter  
- improving our sleeping quality thanks to an european project.  
- centexbel info 'flame retardant hotmelts'  
- unitex magazine 'functionalized hotmelts for different textile applications'  
- master thesis 'study on textiles with phase change materials' by mert ozcelik. ghent university and istambul technical university.  
  
dissemination material  
  
for the purpose of effectively disseminating the project, the following materials were produced:  
- project logo: a project logo has been designed at the beginning of the project to be used in all dissemination material to enhance easy identification of the project among the members of the target groups. this logo can serve, as well, as product logo in the post-project phase the project logo was registered as a trade mark by ecus with the acceptance of the other partners.  
- project leaflet: a three-fold project brochure has been created; it describes the consortium partners and provides their main contact details as well as the general and technical objectives of the project. the brochure is user-friendly, compact and easy to understand.  
- project banners: a banners have also been prepared in order to properly disseminate all4restproject on national, european and international fairs and exhibitions it was used in ecus booth in hostelco to promote all4rest.   
- project presentation template: as a general overview about the project and its objectives, a presentation has been produced, downloadable from the project's website. this describes the general objectives of the project, the participating organizations and gives an outlook on the intended functionality of the system. this presentation can be used by all partners as starting point and it can be enriched based on the needs of the partners and the dissemination event.  
- project dossier: a project dossier was prepared with all the project results to serve as dissemination material for fairs at the end of the project. the dossier was produced in spanish and in english because it has been used for the first time in hostelco fair in barcelona as final dissemination event.   
- demonstrators: seven demonstrator prototypes have been developed using the technologies developed in the frame of the project: prototype materials finished with renewable hotmelts, prototype materials with biofibres / enzymes nanofinished, fabrics finished with microcapsules for thermal comfort improvement, textiles finished with scentic microcapsules, textile printed with electroconductive inks, heatable textiles with electroconductive threads, a mini-mattress with temperature and pressure sensors. the goal of these demonstrators, besides validating the technologies, is to provide a clear view of the potential use of all4rest in the respective market segments. they were shown in ecus booth in hostelco fair. the demonstrators will be used as the major dissemination tools of the project results after the project conclusion.  
  
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the project has also been included in website platforms such as systex http://www.systex.org and the textile surveillance system http://www.tendenciashabitat.es

# ALL4REST

Project Acronym: ALL4REST

programme & topic: FP7-SME SME-1

Most frequent returning words in objectives:

* ('project', 66)
* ('textile', 23)
* ('dissemination', 22)
* ('all4rest', 20)
* ('textiles', 19)
* ('materials', 17)
* ('fabrics', 16)
* ('website', 16)
* ('developed', 15)
* ('partners', 15)
* ('comfort', 13)
* ('thermal', 13)
* ('system', 13)
* ('mattress', 13)
* ('results', 13)
* ('events', 12)
* ('fair', 11)
* ('rest', 10)
* ('activities', 10)
* ('development', 9)
* ('systems', 9)
* ('hotmelts', 9)
* ('sensors', 9)
* ('sleep', 8)

executive summary:  
  
the present project, all4rest, is focused on the development of comfort-improved rest systems, using non-obstrusive technologies that promote deeper, more restorative sleep and prevent nocturnal awakenings. the successful solutions reduce awakenings and/or reduce time to sleep after an awakening and reduce sleep onset latency. within the global comfort improvement, physical and thermal parameters have been investigated, establishing quantitative and qualitative evaluation of comfort and sleep quality system. to achieve it, use of biomaterials and research of new ones, eco-friendly technologies and processes in fabrics destined to rest allow the development of new products focused to obtain an improved rest system. specific techniques of comfort evaluation have been implemented in final products characterization and validation. in addition new high value-added end products have been developed, based on the specific properties of the novel materials and technologies used. this route of constant innovation in products and processes is essential to strengthen the european textile industry and especially the sme companies.  
  
project context and objectives:  
  
all4rest was focused on the development of comfort-improved rest systems, linking enhancement of tactile and thermal comfort given by innovative textile-based solutions with best sleep quality described by end-users. physical and thermal parameters were investigated, establishing quantitative/qualitative evaluation of comfort and sleep quality in each textile system.  
  
to achieve it, the solutions developed in all4rest have been based mainly in research on:  
- new biofibres.  
- integration of pcm (phase change material)-based thermoregulating systems.  
- new/functional hotmelts (hms).  
- heatable textiles with electroconductive inks.  
- microencapsulated scents for aromatherapy, and   
- sensoring/monitoring of body temperature/pressure.  
  
objectives:   
  
all4rest project was structured under 4 specific r&d lines:  
- research on 'green' materials and processing technologies, for development of improved comfortable resting systems. (biofibres, nanofinishing, plasma and enzymatic technologies, renewable raw materials used as hotmelts with functional properties).  
- research and development of encapsulated systems for comfort improvement. (suitable materials to develop microcapsules for thermal comfort improvement, suitable materials as scenting additives to develop scent inks for sleep quality improvement).  
- research and development of heatable/cooling textiles for thermal comfort improvement. (suitable additives to formulate electroconductive inks, heatable/cooling textile systems).  
- development of sensors into textiles to monitor the sleeping quality, and react with a heatable/cooling device included in the rest system. (measure the body movement and the room temperature to react with a heatable/cooling textile system, also developed in the project, improving the thermal comfort).  
  
during the period covered by this report (15 months, from 01/10/11 to 31/12/12) the objectives above described were covered through the following work performed according to the work program:  
  
- wp1 was focused to the development of different samples of knitted fabrics with selected biofiber-based textile materials. some fabrics and compositions were investigated and also treated with enzymatic and finishing formulations to enhance tactile performance. quantities of auxiliary chemicals and functional products for these treatments were established. general properties of the unfinished/finished fabrics were tested (washing fastness, antimicrobial properties) and some successful samples of knitted fabrics were obtained. on the other hand, functionalization and coating of mattress ticking fabrics with hotmelts was, in some cases, successful. it was concluded that flame retardant and antimicrobial additives can be added via the use of a double screw compounder. the application of the (functionalized) hotmelts on the mattress ticking substrates can easily be done with the slot-die technique at temperatures around 140 â°c. the properties of the flame retardant (fr) compound were assessed via a smouldering cigarette test and the flame test (match flame equivalent). obviously, the type of hotmelt and the coating thickness has also an influence: the thicker the coating layer, the better the ignition is suppressed. hotmelt applications were done always like a coating and some mattress ticking with flame retardant properties were obtained.  
  
- wp2 has investigated different formulations for finishing fabrics (mattress ticking) with novel-reactive phase change materials (pcm) systems with enhanced linking force between binding resins and fibers. thermal capacity of each application and sample was evaluated in order to select the best fabric substrate and the right concentration of microcapsules in the padding solution. also the influence of the presence of softener on the impregnation bath was tested. measurements and tests were done using advanced analytical techniques such as scanning electron microscope sem (the best way to observe the presence of microcapsules and preferred because we are dealing with small entities, microcapsules), differential scanning calorimetry dsc (used to measure the phase change temperatures and energy storage capacities of the pcm-loaded textiles) and thermographic camera (used to observe the thermal properties of the pcm-loaded textiles). washing resistance was also tested. within the study of scenting additives, some screen printing tests were successfully carried out adding microencapsulated fragrances, testing their washing fastness (inkjet printing of encapsulated scenting additives is not possible due to clogging of nozzles). some scenting or thermoregulating pcm-based fabrics were done.  
  
- wp3 was focused on optimizing electroconductive coatings and printings developed in the first period of all4rest, but also to study integration systems of metallic yarns on fabrics. good conductivity in inkjet printing could be performed on the basis of silver particles. sintering was investigated and can be performed to develop textile-based heating elements (by printing on pes-foil or pa-foil and its subsequent lamination on textiles). by applying a voltage of 5v temperatures up to 70â°c could be obtained. the reductive deposition of metal salts directly on textiles works well. therefore it was concluded that inkjet printing is a very flexible technique in terms of pattern design. this is an advantage that also the embroidering technique has: it was used to make a resistive heating element with stainless steel yarn on ticking fabric. the pattern design can easily be adapted to the requirements of the heating zone. embroidery has proven to be a very flexible and promising textile technology to manufacture heating elements. some heatable textile-based solutions to be integrated further into a mattress were obtained and a modellisation for heatable textiles included in a textile layered-structure was developed..  
  
- work done in wp4 allowed the design and building of a sensor system that enables the measurement of the temperature and movement of a sleeping person. different material pairings were evaluated and the best outcome was achieved with a combination of different metallic yarns. next to temperature sensors, movement sensors have been developed which can detect a movement of the sleeping person. the programming of software for storing the movement during the whole night in comparison with the time was possible. the movement and temperature sensors can be used to quantify the quality of sleep. the sensors have been developed for large-scale manufacturing. therefore a sensor principle for the movement sensor has been chosen which is based on the conventional production of the mattress. the theoretically up scaling was done for the prototype obtained in all4rest. in further projects derived from all4rest, the production chain for the mattress with integrated sensors has to be prepared taking into account the special needs of the production company.   
  
- the demonstration wp5 aims at validating the rtd work packages results. innovations developed in wp1 to wp4 of all4rest were characterized and validated by different analytical methods (including standardized tests, own methods, clinical procedures, consumer panels and surveys). it was observed that the application of finishing processes (like hotmelt coating or scenting microcapsules) was in direct relationship with a decreasing of handle/tactile performance (evaluated by kes). on the other hand, finishing with nanocompounds increases handle feeling, but also the use of biofibre-based textile materials (bamboo, chitosan or soya) when compared with a usual textile material (cotton). regarding thermal comfort, skin model (to measure ret and rct) characterization showed that the application of a pcm-based finishing on mattress ticking samples was in direct relationship with a wide increasing of the thermal insulation when compared with reference samples. it also seems that the use of new biofibre textile materials on knitted fabrics can improve their breathable properties and their moisture management performance. with all the results obtained within tactile and thermal comfort evaluation of different all4rest samples and prototypes (including the auto-heatable textile prototypes developed in wp3 with capabilities to be continuously heated at a desired temperature), it seems that new mattresses including new pcm systems for thermoregulation effect and new nightwear cloths manufactured with bio-based textile materials could be realistic solutions, with clear possibilities to be integrated in the same rest system at industrial scale.   
  
clinical tests and consumer assessment were also carried out taking into account the experimental character of some all4rest developments and the prototyping performance of them. by this reason, clinical procedures (objective/analytical results) were restricted to test some different mattresses and the information obtained was complemented with a consumer assessment (subjective results) on the same samples. subjective information collected was also completed with a consumer survey on the main developments, materials and advantages of all all4rest solutions. objective and subjective positive sensations were assessed by potential customers to select a mattress with an internal spring system as preferred versus an internal foam system. people who slept on a spring-system based mattress said that their feeling and rest sensation was better, and polysomnographic (psg)/actigraphy (act) tests results were in the same direction. in addition, direct positive relations established by kes+consumer survey regarding improvement of tactile behaviour on knitted fabrics and direct positive relationships established by skin model+manikin/thermography+consumer survey regarding improvement of thermal behaviour on mattress ticking were also obtained.  
  
- wp6. training, dissemination and exploitation, is in progress since the very beginning as dissemination activities are considered crucial. among the different activities performed during the second period, we can point out the maintenance of the project website, the development of the project dossier, the dissemination of the project in several events and overall the final dissemination event in hostelco fair in barcelona.   
  
- wp7. project management is also in progress since the beginning of the project. among the main activities performed were the signature of the consortium agreements, the transfer of the pre-financing and mid-term funds, the organization of the consortium meetings and also the organization or conference calls for monitoring the work and a list of actions updated for the same purpose.  
  
project results:  
  
all4rest has achieved most of its objectives and technical goals for the period with relatively minor deviations. regarding wp1, it was concluded that can be possible to develop new biofibre-based cloths for nightwear with improved tactile behaviour; on the other hand, commercial available bio-based hotmelts are not widespread and only 2 bio-based polyamides (grades of uni-rez) from arizona chemicals and an experimental grade (under nda) fulfill the processing requirements; however, functionalization can be obtained through fr and antimicrobial additives can be added via the use of a double screw compounder and fire retardant coated samples were successfully developed. foreseen lamination tests were not realized because it was not required to bond fabric with foams along the project. in wp2, application of scenting products and pcms was successfully achieved on fabrics through different finishing/printing (padding, screen printing) techniques, and only inkjet printing was unsuccessful (due to clogging problems on nozzles of the printer device). in wp3 it was possible to develop heatable textile-based devices with textile techniques (e.g. embroidering and printing of electroconductive inks) and in wp4 a combination of movement/temperature sensors were developed and integrated into the same textile system (mattress). in wp5, not all the developments and technical solutions obtained in all4rest were tested with all the analytical tools (due to technical reasons: metallic wires and electric connexions on heatable or sensoring textiles, industrial size of a sample required for a specific test, etc.), but characterization of tactile/thermal improvements and its relation on objective/subjective assessment of better comfort was successfully achieved. in some cases, there was coincidence between empirical data and perception of customers. psgs/acts and consumer's assessment were found as powerful tools to validate rest products from an objective+subjective point of view.  
  
at the end of the project, all the developments and technical solutions obtained were analysed about an estimation of their industrial cost and capabilities to be manufactured at industrial level, with positive conclusions for some of them (biofiber-based knitted fabrics, new pcm-finished mattress ticking and mattresses, integration of heatable devices, textile sensorizing for clinical purposes, etc.). different technical developments have been proposed for a demo fp7-sme-2013 project (proposal all4restgo2market): a) mattresses with thermoregulation performance, b) pyjamas manufactured with biofibre-based knitted fabrics giving soft touch/better hand (also skin benefits) than conventional materials, and c) bedclothes manufactured with biofibre-based yarns looking for enhanced touch/comfort or finished with pcms.  
  
potential impact:  
  
the developed research generate high societal and market impact for the european smes, and enable major technological breakthroughs not only in the rest products market but in other sectors that could take profit of the developments such as technical textiles for cloths and automotive industry.  
  
main dissemination activities and exploitation of the results.   
  
the dissemination activities of the project have been consistent with the originally planned dissemination activities of the project proposal as well as with the dissemination action plan. the partners, as depicted in table 1 below, have used an array of mediums and tools in order to successfully disseminate the project to the relevant audience. the presentation of prototypes and other relevant technology has been available for partners and has been promoted to customers and other stakeholders. in order to raise public awareness of the proposed technology, the partners have performed pre-marketing stimulation activities such as editorials, conference papers, sales, presentation in fairs and marketing contact with potential customers internationally, through the use of trade press, trade bodies and plant suppliers, approvals bodies, consumer groups and regulatory authorities. activities include technology demonstration events, major exhibitions, stimulation events, presentations and conference papers, databases and the distribution of project promotional material.  
  
events   
  
the project was noted with overall success in relation to the participation of the partners in events. a variety of different events took place such as conferences, participation in exhibitions and fairs as well as participation in seminars. the technology of the project has been presented thoroughly and throughout these events, with the partners aiming at maximizing the visibility of the project results. the partners also participated in notable and world-renowned brokerage events. the events helped to promote the project towards targeted audiences via personal fair stands and promotional material.   
  
in relation to external conferences, the partners have participated in world-renowned conferences such as the european technology platform for the future of textiles and clothing annual conference held in march 2011 in brussels, the infoday 'ten successful stories of applied research' alcoy, march 2011, smart textiles salon in ghent (belgium) in april 2011 the fair techtextil in frankfurt may 2011, itma fair (textile machinery fair) in september 2011 in barcelona, habitat fair in valencia, september 2011, 6th european congress 'surf on the waves of innovation in coating and lamination', belgium, september 2011, on the road to a bio-based economy. belgium, october 2011, bayern innovative kooperationsforum for textile&sensorik in tegensburg (germany) october 2011, the systex conference in belgium november 2011, aachen-dresden international textile conference aditc, november 2011, textile innovative symposium and fair furth (germany) february 2012 where the sensors and the project leaflet were presented, the infoday market trends surveillance, alcoy march 2012, smart fabrics conference, miami usa march 2012, infohappenings 'hotmelts' zwijnaarde (belgium), june 2012, business convention in troyes france called citext held in june 2012 the business convention brings together every 2 years more than 300 international participants, users or suppliers of technical textiles. during these days b to b meetings are organized with participants from 8 different countries: belgium, france, germany, italy, spain, switzerland, uk and usa. symposium 'smart textiles and embroideries', bregenz (austria), september 2012, reha care fair dusseldorf (germany), hostelco fair, barcelona october 2012 where a corner of ecus booth was fully dedicated to show the project and its prototypes. a dedicated leaflet was also developed as a dossier of all the project developments and also some totems with project information. ecus customers had the opportunity to learn about the project and to know about ecus perspectives. smart medical textiles aachen (germany), november 2012, 'the use of functionalized hotmelts for different textile applications' aachen-dresden congress, november 2012, medizintechnik symposium, dresden (germany) december 2012, promotion of the project results related microcapsules through devan most important customers on bedding market. december 2012.  
  
specific mention must be made in relation to the type of audience each event was targeted, since the dissemination activities performed approached an array of interested parties, coming from different fields and areas of interest. universities and academic institutions, technology institutes and industrial partners are some examples of the type of audience the dissemination activities aimed at. specifically for industrial partner, it is notable to mention that events took place such as participation in conferences, fairs and exhibitions satisfying industry.  
  
all events had a wide geographic approach, targeting both audiences in europe and the us. the well-received reactions of these audiences demonstrate that the all4rest technology is indeed innovative in various contexts and not only related to improving the quality of the rest but also in medicine, car industry, technical textiles for hard conditions.  
  
publications   
  
publications, either in the form of press releases or as scientific papers with the intention of being published and/or in the process of being published, have played a significant role in the dissemination of the project. the project has been disseminated in various newspaper articles, both in hard copy and on the internet. many articles published concerned the distribution of the projectâs press release in notable magazines, scientific journals and industrial blogs.   
  
press releases were aimed primarily at the local audience, particularly professionals and industrial stakeholders. this medium has proved particularly useful since it has disseminated the project at large to a wide public which would not be easily identified via standardized methods of dissemination such as events and scientific conferences. all partners have maximized the potential for dissemination and visibility via the project's press release. a variety of academic, online and popular journals have published the all4rest press release.  
  
some of the articles published were:  
- article in valencia i+d website  
- article in kmm-vin newsletter (knowledge-based materials)  
- aitex magazine  
- internet melliand newsletter  
- improving our sleeping quality thanks to an european project.  
- centexbel info 'flame retardant hotmelts'  
- unitex magazine 'functionalized hotmelts for different textile applications'  
- master thesis 'study on textiles with phase change materials' by mert ozcelik. ghent university and istambul technical university.  
  
dissemination material  
  
for the purpose of effectively disseminating the project, the following materials were produced:  
- project logo: a project logo has been designed at the beginning of the project to be used in all dissemination material to enhance easy identification of the project among the members of the target groups. this logo can serve, as well, as product logo in the post-project phase the project logo was registered as a trade mark by ecus with the acceptance of the other partners.  
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# PROFITEX

Project Acronym: PROFITEX

programme & topic: FP7-NMP NMP-2008-4.0-9

Most frequent returning words in objectives:

* ('fire', 46)
* ('system', 35)
* ('layer', 29)
* ('task', 28)
* ('data', 26)
* ('button', 22)
* ('work', 21)
* ('components', 21)
* ('fabric', 21)
* ('results', 20)
* ('signal', 20)
* ('requirements', 19)
* ('textile', 18)
* ('test', 18)
* ('design', 17)
* ('variant', 17)
* ('profitex', 16)
* ('jacket', 15)
* ('user', 15)
* ('fighters', 13)
* ('fighter', 13)
* ('project', 12)
* ('transmission', 12)
* ('firefighters', 12)

executive summary:  
  
the aim of project profitex was to support fire fighters in their perilous work with a system that supplies mission-relevant information without overwhelming the fire fighter. the system comprises two main components:  
  
1. a fire fighting jacket with integrated electronics and a braided security rope, called smart lifeline which is able of transporting data. the jacket comprises electronic devices like an infrared camera, movement and localisation sensors and a volcano button integrated into the jacket sleeve. wire-bound data transfer are be used since wireless communication is difficult over long distances and through several walls of a building. a security rope carried by fire fighters during a mission shall be equipped with data transmission capabilities. this allows information to be sent outside to the command post and back to the fire fighter. by monitoring several parameters of the fire fighters condition like his movement pattern and stance, problems can be detected immediately. the fire fighter himself is supplied with the possibility to navigate even in smoky environments thanks to the infrared camera and the positioning system implemented into his equipment.   
  
2. information will be displayed to the fire fighters, their group leaders and the commander outside the building. the amount and type of information supplied are being carefully chosen, considering the physical danger and psychic stress fire fighters are opposed to. work safety of fire fighters shall be increased, thus lowering the number of work-related accidents and casualties. fire fighting missions will be more efficient using the system.  
  
project context and objectives:  
  
fire fighting is a perilous job which brings people and equipment to the limits. each year over 5.000 deaths are caused by fires in europe alone, and among these dead are more than hundred firefighters. providing technology for the professionals who fight these fires is the mission of the eu-funded project profitex (http://www.project-profitex.eu).  
  
usability and user-centered design are a key point in the project. there are different roles and requirements in a fire-fighting intervention:  
- the firefighter himself inside the building;  
- the group leader, monitoring several teams of firefighters in the building;  
- the mission commander, located outside the building, coordinating the intervention.  
  
project results:  
  
description of work  
task t 1.1 - workplace studies  
  
in t 1.1 the consortium will conduct empirical studies of the working conditions of firefighters as relevant for the project's rtd objectives. the focus of these studies is on the actual characteristics of fire fighting operations but there are also other relevant aspects such as professional training, assessment of new technologies and adaptation of operational procedures within fire fighting organisations. the objective of these studies is to establish an empirically grounded understanding of:  
  
- the operational constraints for the systems to be developed (the what)  
- the constraints for an effective participation of the available firefighters in the design process and for the effective appropriation of the developed technologies into operational use (the how)  
  
results achieved in wp1  
profitex adopted the following focused objectives regarding workplace studies:  
1) validate existing results and adapt where necessary;  
2) create shared understanding among profitex partners on firefighting work practice;  
3) conduct complementary workplace studies where this provides substantial benefit.  
  
this exercise was covered by the german tv channel 3sat for their science program hitec: http://www.3sat.de/page/?source=/hitec/158804/index.html  
  
description of work  
  
task t 1.2 - user requirements  
  
in t 1.2 will elicit user requirements focusing on the work situations identified and described in d 1.1. these user requirements are distinct from system requirements in that they do not imply any particular solution but simply state the problem or challenge for which the users, here the firefighters, require a solution. this task represents an important analytical effort to understand the actual needs of fire fighting operations in order to guide the search for and the assessment of possible solutions without focusing on any particular solution too early. of course, the limited resources present in projects such as profitex require focusing efforts on one or few solutions eventually. for the user requirements, the workplace scenarios described in d 1.1 as well as the project's technological capabilities described in d 2.1 will help in focusing our efforts.   
  
t 1.2 will report the user requirements in d 1.3.  
  
results achieved in task  
  
these requirements were written with respect to volere requirement standards. this requirement standard distinguishes itself from other requirements standards by testing the requirements while they are being written. this is carried out by looking associating a fit criterion with each requirement. this fit criterion is used to determine if the proposed solution can fit with this requirement or not.  
  
description of work  
  
task t 1.3 - prototyping and participatory design  
  
in t 1.3 the consortium will engage firefighters and other stakeholders in a participatory design process. this activity is based on the understanding that usable and eventually accepted designs do not result from the implementation of specifications that have been obtained before the design phase. instead, successful designs result from many iterations of putting the artefacts to work in the hands of the users and obtaining their feedback. to enable this process even before functional system prototypes become available, t 1.3 will prepare and organize a series of workshops where the use of systems or system components during fire fighting operations will be simulated with different means, based on the prototyping approaches developed in the wearit@work project. in particular this includes simulating fire fighting operations with the firesim prototyping tools, allowing multiple actors to use virtually simulated future technologies in either a fully virtual or a mixed-reality environment, i.e. an augmented physical training facility or a virtual building. the purpose of these activities is providing to the firefighters as rich as possible an experience of using future technologies in realistic usage situations and thus enabling them to provide design-relevant feedback in a meaningful way.   
  
results achieved in task  
  
in addition to a continued improvement of the firesim prototyping platform, from version 1.3 at the midterm review to version 1.6 at the final review, with virtually hundreds of bug fixes and improvements, two major additions were made during this time. first, the command post system prototype was implemented as part of firesim, enabling interactive testing with very limited effort and very shortly after the concept had been defined. this implementation was also used in the studies reported as part of t1.1.   
  
description of work  
task t 1.4 - system requirements  
  
in t 1.4 the specific requirements for a system addressing a defined set of user requirements from d 1.3 will be described. the first step here is to select a coherent subset of requirements from d 1.3 that profitex will address. this selection will depend on the project's feasibility evaluation regarding different technological options in wp 3 and a prioritization of requirements by the firefighters. similar to the user requirements, the system requirements will not specify a concrete implementation but provide measurable criteria for judging whether any given system meets the requirements.   
  
results achieved in task  
  
task t 1.5 - economic analysis and financial planning  
  
with the aim to develop an economic analysis which supports assumptions made on demands in the short- and medium-term, texclubtec will provide market data and data of potential customers and fire brigades.  
  
results achieved in task  
  
within this task potential customers of profitex were identified. beside fire brigades texclubtec (tct) identified army, police, national and regional civil defence organizations and industrial companies with own internal fire fighter services. the army and police need a different configuration of e.g. sensors to be used in their application scenarios. search & rescue scenarios in unknown and dangerous environments can be transferred immediately. also the concept of the information centre - the command post - is very useful for the other target groups. while the main focus of a special force of the police or army is not fighting fire but rescuing people out of dangerous situations and neutralizing one or more suspects in not predictable areas, the profitex system enhances army and police operations due to the advanced information technology implementation.   
  
description of work  
  
task t 1.6 - user reference group: workshops and online community  
  
t1.6 deals specifically with organizing an exchange of knowledge and experience among the members of the user reference group on topics relevant to the profitex project. while the aim of t1.3 is to engage end-users in hands-on design activities one organization at a time, t1.6 focuses on bringing the different perspectives from end-users together by fostering an open debate among the members of the user reference group. this exchange will be facilitated by two principal means: 1) dedicated annual workshops where representatives from all end-user partners as well as the technical partners will work on principal aspects of the project and 2) an online community where a continuous exchange is motivated and facilitated, focusing more on a sustainable lively discussion than on the exchange of abstract information.   
  
results achieved in task  
  
the realization within profitex of not being able to develop functional physical lifenet beacons let to a re-evaluation of the reference user group (rug) strategy. as explained above, the inability to develop lifenet beacons within profitex required the search for an alternative localization technology and the adaptation of the navigation support system to this technology. to this end, a more targeted technical discussion was required which was only practical within a smaller group of end-users and domain experts familiar with challenges faced and available to engage in a sustained technical discussion. therefore, this discussion was conducted with fire fighters from heat and other domain experts from within and external to the profitex project.   
  
work package 2 - technology development  
  
objectives  
  
within this work package the planning and design of the single components will be done. starting from a definition the components will be planned. furthermore the components will be manufactured, and in combination with wp 4 they will be tested. in the end a decision about which components will be used for the next steps will be made. this will finally lead to a system design, that can be tested under real conditions.  
  
description of work  
  
task t 2.1 definition and planning of single components  
  
the following technical parts are essential for the whole concept.  
 power supply system  
- definition of a modular component system  
- evaluation of the data volume  
- definition of internal (jacket based ) interfaces (textile bus system)  
- definition of the jacket to lifeline interface  
- definition of buttons and display (hid)  
- definition of system behaviour in case of system failure  
- security aspects ('is there any danger coming from the system?')  
- definition of performance  
- results achieved in task  
  
requirement plan  
  
protective clothing is closely related to the clothing sector. potential solutions and product designs are complex due to their intended purposes. considering protective clothing for firefighters there is mainly the task of heat protection and the transmission of sweat. to fulfill all these tasks standard fire-protective clothing consists of several layers. the layer system depends on the specific model of a garment.  
  
basically it is structured into  
- outer shell  
- gore-tex membrane  
- inner liner  
  
requirement plan  
  
in order not to endanger firefighters, protective clothing must meet the following requirements.  
  
- thermal protection  
- moisture and hot steam barriers  
- re-drying and sweat permeability  
- weight and ergonomics  
- visibility  
- robustness  
- haptic  
  
description of work  
  
in this task all components are manufactured by the technology partners. if necessary, not only one technical layout will be manufactured, in certain cases also two or even three different approaches might be necessary.  
  
results achieved in task  
  
smart lifeline development  
  
the development of the smart lifeline was done in the course of a phd thesis. all images and results describing the smart lifeline development are taken from [eic12] with the author's permission.  
  
conventional data cables  
  
in a first step regular data cables have been analysed and their main components were identified. an electromagnetic shielding (in this case a metal-coated polymer foil) is wrapped around the cable. the outer layer is formed of an extruded polymer jacket.  
  
smart lifeline concepts  
  
the smart lifeline has been developed in two variants. variant a consists of a textile data cable with no electronic devices in between the two ends of the cable. the main goal in the design and production of this data cable is to research the integration of data lines in braided structures. critical parameters like cable resistance and signal transmission quality are to be assessed with this prototype.  
  
the components of the variant a prototype are as follows:  
- core rope (for mechanical stability)  
- functional layer (holds the electric leads  
- insulation layer (separates the functional layer and the emi shielding layer)  
- emi shielding layer (against electromagnetic disturbances)  
- mantle layer (mechanical protection).  
  
the elements in this design are as follows:  
- core rope (for mechanical strength)  
- woven narrow fabric with electrical leads  
- adaptor, bottom shell  
- adaptor, top shell  
- electrode channels (here the electrodes of the electronic device can be plugged in)  
- insulating braiding layer  
- emi shielding layer  
- mantle layer  
- electronic device  
  
measurements procedures  
  
after producing the smart lifeline prototypes each one was tested considering its signal transmission capabilities. the smart lifeline variant a and b were subjected to the the following tests:  
- laboratory tests (variant a and b prototypes)  
- insulation test (testing against short-circuits)  
- ohmic resistance measurement (dc resistance)  
- impedance measurement (ac resistance)  
- signal attenuation (signal loss from one end to the other)  
- cross-talk  
- practical tests  
- usb data transmission test (variant a only)  
- video signal transmission test (variant a and b)  
- displays the equipment which was employed during the tests.  
  
insulation test  
  
two variants of the variant a prototype were produced. the electrical leads in the functional layer were realized using four shieldex yarn (235 dtex) in one variant and copper wire (d = 0.15 mm) in the other variant. an insulation test was performed. this was done by testing the connectivity between 1a-1b-1c-1d-1m. only 1a is supposed to show a connection. if any other pairing shows an electrical connect, a short-circuit has occurred. next 2a, 2b, 2c, 2d, 2m are tested and so on.  
  
ohmic resistance measurement  
  
cross-talk  
  
cross-talk is a phenomenon which occurs between neighbouring electrical leads. a signal flowing through a conductor induces a signal in the neighbouring lead, resulting in a signal loss in the signal line and noise in the passive line.   
  
practical test 1: usb data transmission test  
  
to show the capability of the braided data cable (variant a) usb connectors have been soldered to the cable. usb contains four data leads and a mass lead, same as the variant a prototypes. therefore variant a prototypes have been confectioned with usb type a and usb type b plugs to connect a notebook and an external harddrive.  
  
practical test 2: video signal transmission test  
  
with both the variant a and b prototypes of the smart lifeline a practical video transmission test was conducted. the signal was sent from a source (dvd player) to a tv by using an analog composite video signal feed. composite video requires only two eletrical leads - one for the signal and one for mass. the variant a prototype was confectioned with cinch connectors. the four data leads were all soldered to the signal pin of the cinch connector, the emi shielding layer was connected to the mass.   
  
insulation test  
  
the insulation test was performed on both the variant a prototypes (braided data cable with wither copper wire or silver-coated polyamide leads). the prototype with copper wires exhibited no short-circuits, all four leads and the emi shielding are clearly separated.  
  
ohmic resistance, impedance, signal attenuation, cross-talk  
  
 for comparison all measurements have also been performed on a standard cat-5 ethernet cable. since signal attenuation and crosstalk are effects which depend on the signal frequency, these measurements were taken at 100 khz, 1 mhz, 10 mhz and 50 mhz each.  
  
practical test 1: usb data transmission test  
  
two variant a prototypes were outfitted with usb type a and b plugs, one variant a prototype was confectioned with usb type a-a plugs.  
  
practical test 2: video signal transmission test  
  
the images from the source (dvd player) could be transmitted clearly, there were no disturbances in the video image. this demonstrates that the textile data cables are capable of transmitting a clear video feed.  
  
beacon demonstrator  
extensive research on local indoor positioning and localization has been done at labor to verify the possibility to integrate a powerful computational unit into the sll beacons and able to provide global and/or local position information with high resolution and accuracy.  
  
hardware  
the development platform previously selected for the beacons development was dropped once the localization requirement was taken out from beacons specifications. a more simplified architecture and hardware was then chosen.  
  
firmware  
  
the firmware flashed into the beacon is able to calculate the retreat path along a series of beacons using an algorithm based on dijkstra calculation. it also sends and receives messages to the host coordinator, the tms1 in the display, and records the positions of all the other beacons deployed in the gui software. it also drives the two green and red leds to signal the fire fighter proximity (red led) and the route by flashing the green led. there is also a local temperature sensor constantly monitored by the cpu; once the temperature is above a preset threshold, the beacon is automatically excluded by the retreat path and each beacon modifies its routing map accordingly. the routing map is also updated every time a fire and/or a broken path is active in the scenario. all the communications are managed by the zigbee module and coordinated by the cpu.  
  
gui software pc  
  
the gui interface is designed to simulate the deployment of a number of beacons in a sar mission and test the real beacons behaviour when different dangerous situations take place like the presence of a fire, a connection path between two beacons is broken or when a beacon senses a high temperature over a certain threshold.  
  
fire fighting jacket development  
  
the main goal is to investigate a textile based interface for the fire fighters' protective clothing. it can be used for communication between fire fighter and corresponding system enabling to transmit data to both the fire fighter inside the building and the group leader outside the building. the fire fighters' garment is the medium for integrating the interface and electronics to build up an infrastructure to distribute data and energy. in that way, it will be possible to locate the fire fighter. the data will also be used to monitor the posture and activity of the fire fighter (stance recognition, activity index).  
  
plan for the textile keypad  
  
when combining the hid with a standard fire fighters' garment it does not mean to destroy the garment's functionality, but to full fill the exact statutory provisions and norms. for instance to reach the thermal protection of the fire fighters exposed to 1000â°c and to maintain a constant body temperature heat regulation mechanisms with re-dryable and sweat permeable materials.  
  
structure of the hid  
  
the hid is realized in three devices which are placed at the forearm at the fire fighter garment. every device is composed of the following:  
  
- water resistant cover protecting the conductive materials against influences like extinguishing water from outside  
- relatively broad and wide knitted spacer fabric to get electronic contact by pressing the device (even wearing thick fire fighters` gloves)  
- button matrix with the opportunity of nine contact points  
  
the following technology is used for building up the textile matrix switch. the hid consists of three layers.  
  
water resistant cover:  
  
to protect the electronic components from outside influences there is an upper functional layer. this water-resistant cover is made out of waxed awnings to avoid influence on the from outside such as water and heat. to produce it there are two waxed awnings sewed together. one of them forms a quadratic button whereas the other part forms the ground.  
  
spacer fabric:  
  
this functional layer is followed by a spacer fabric to ensure a high material flexibility of three-dimensional feature: spacer fabric which is manufactured by mã¼ller textil which has lot of experience in the textile warp knitting technology. this fabric is 10 mm thick.  
  
button matrix:  
  
the third layer consists of a button matrix including silvercoated polyamide (pa) yarns on the inside of the buttons: button matrix. the button matrix consists of two fabrics. by rotating the bottom layer around 90 degrees, a matrix can be formed. the bottom layer has stripes of conductive yarns that connect through a tape with wires (special narrow fabric from offrayâ®) with the usb-connector. a housing of the electronic interface is needed to encapsulate the electronic and the cabling.   
the button matrix is structured like following:  
- upper function layer  
- knitted fabrics  
- knitted fabric with several stripes of conductive yarns  
- bottom function layer  
  
process  
step tools which are neededâ main process textiles which are neededâ pictogram  
1 scissors cutting 2 knitted fabrics   
  
- non-woven   
- fabric with several stripes of conductive yarns   
  
2 hot iron (140â°c) bonding fabric   
- non-woven   
- fabric   
- knitted fabric with several stripes of conductive yarns   
- unformed upper function layer  
  
3 former plate, punching tools thermoforming unformed upper function layer   
upper function layer  
  
- bottom function layer  
  
the bottom function layer consists of the following three fabrics containing diverse properties:  
- woven fabric with several stripes of conductive yarns  
several paths are tightly woven with silver coated conductive yarns into a textile, produced with pes-yarn on the web loom.  
- supporter fabric  
the upper function layer can be attached to the supporter fabric to guarantee the required stability for the keypad.  
- awning fabric  
apart from being a supporter fabric this awning fabric also offers additional textile stiffness for the keypad and a hard ground.  
  
position of the human-interface device inside the fire fighter jacket  
  
generally the layer system depends on the model of the jacket. the layer system is structured like following:  
1.) shell  
2.) gore-tex membrane  
gore-tex membrane is used to guarantee the waterproof despite it is breathable so that it prevents the fire fighters against wind and super heated steam.  
3.) interlining  
  
the hid in form of an additional layer should be placed between the gore-tex membrane and the interlining. this way the hid is protected against influences like extinguishing water and rain as well as the high temperatures from outside.  
  
materials and methods  
  
one of three layers is a knitted fabric with several stripes of silver coated conductive pes-yarn inside. to get the form of the button matrix the knitted fabric including the conductive stripes has been heat set with a heated press machine like mentioned above.  
  
the test apparatus has the following characteristics:  
  
the tactual finger is a steel pin with a diameter of 10 mm coated with foam which is driven by an electrical motor and operated with a sinusoidal output.  
  
parameters technical details  
  
cycle sinusoidal form  
tactual finger steel pin with coating  
underlay foam pur f46  
switching voltage 5 voltage  
measuring frequency 200 hz  
pulse frequency 0,7 hz  
material button matrix  
  
results  
  
every button has been tested on its pressing stability for more than 80.000 switching cycles and have been finished manually. it should be noted that the thermally formed button being tested has to retain its switching function over the testing time. but the surface and material stability of the buttons become severely affected after this high switching numbers which has an effect on sagging of the thermally formed three layered knitted fabrics.  
  
the aim of both tests was to provide a relation between human sensing and the influencing parameter  
- thickness of surface material (number of layers)  
- height of transparency curvature (mm): the height of transparency curvature makes the difference between a soft and hard switch.  
  
the haptic tests have been carried out as a questionnaire. the results of the haptic tests are related to the pressing force tests.  
- 2- and 3-layered surface with high transparency curvature (> 4,3 mm) possess a pressure point surface created with more than 3 layers are too stiff  
- low transparency curvatures (< 3,6 mm) do not achieve enough counter pressure  
- sensing of a tactile feedback with the transparency textile compound switch in contrast to the textile switch.  
  
conclusion  
  
although the hid worked well under defined lab conditions, the function of the buttons gets worse and also the tactile feedback of the user was poor in real user tests. like we set up before the major criteria is to have a tactile robust and serious feedback and a rugged electrical contact. it is essential that the fire fighter is able to feel a feedback coming from the button. this textile buttons worked well under defined lab conditions, but while using them in simulations they turned out to be not yet reliable. due to the fire gloves this was a serious problem. also the ruggedness was too weak. the major criteria were to have a tactile a functional button in the meaning of having a rugged electrical contact and also a robust and serious user feedback.  
  
manufacturing of single components (volcano button)  
  
due to the experience of the tests we decided to develop a new version of buttons. it is essential that the firefighter is able to feel a feedback coming from the buttons. we also tried to create a feedback loop using symbols in the display, but this was not usable under fire fighting conditions. also a acoustical feedback, (as known from mobile phones) is not an option due to the noise in fire fighting situations. most important issue was to find a design that avoids unwanted release. so the main issue of this design was to combine the tactile feedback and a kind of protection boarder to ensure that the user will not activate the button unwanted. this is very important because this would affect the systems performance dramatically. the lead to a design we call 'volcano button'. the name is coming from the shape of a volcano, which is pretty the same shape as we realized for the buttons. the button is a assembly of three parts.  
  
the following drawing shows the construction of this assembly.  
  
it was very important to find a design that fits to the needs of fire fighting applications. this means that we have to find the correct dimensions for the volcano button design. we evaluated a lot of different fire fighting gloves and this leads us to a button dimension of approximately 30mm. the first thing was to find a water tight button (ip67) witch have to be electrically solid and also heat resistance.  
  
this finally results in the following parts:  
  
the next important thing to connect these buttons to the ffs unit was to find an interface. therefore it was necessary to convert the bush button signals to usb commands. we used a special electronic for doing this. it is a electronic called avr stick.  
  
description of work  
  
task t 2.3 integration into lab examples  
  
the single components are integrated into textiles. the choice will be made based on the results of the testing in t4.2 the textile material is equal to the material of the end product. electronic components are connected with textile data energy buses to demonstrate and verify the data and energy transmission.  
  
results achieved in task  
  
the main focus of the 'profitex firefighting jacket' will be the practical functionality of the jacket. a general textile integration of the electronic device is possible.  
  
material composition  
  
the 'fire breaker action jacket' contains a liner system with the following parts: antistatic outer shell, gore-tex membrane and lining. 'liner system' means that the membrane is placed loose inverted between outershell and inner-lining. it's not laminated with the outershell. this is a big advantage for having the best and easiest possibilities in integrating all needed components.  
  
gore-tex airlock membrane:  
  
water tightness and high thermal protection are given due to the intact and breathable gore-tex airlock membrane. the membrane also offers advantages like high protection against contaminated liquids and also high reduction of weight.  
  
manufacturing  
  
integration of the necessary technological components into the manufacturing process is possible. always one component gets modified or changed, we have to adapt the steps in manufacturing. main important for all developments is of course the functionality in practice. an important issue to discuss is the washability of the jacket. integrated electronic parts, which are not resistant against water, have to be removed beforehand and integrated again by trained staff. this means additional work and expense, also additional service costs. efficient solutions have to be found. also the wearabilty of the profitex jacket has to be evaluated in practical experience.  
  
task t 2.4 evaluation and drafting of a textile integration standard  
  
the components are evaluated considering their mechanical properties. the compound textile-electronic component is characterised. compiling the experiences of the textile integration, a standard for the integration of electronic equipment into fire-protection textiles will be drafted. considering the future production of the profitex system, production methods and production costs will be evaluated in this step as well.  
  
deliverables will be:  
d2.8 report on the evaluation of the system design  
d2.9 standard for the integration of textiles into fire-protection components  
  
results achieved in task  
  
a certification for the profitex jacket has not been done so far, as this certification would also include the certification for the electronic integrated devices and components.  
  
description of work  
  
task t 2.5 signal-processing for components  
  
vut and eth have experience and ongoing research projects in pattern recognition and signal processing to interprete and analyze data from bio-sensors.  
  
results achieved in task  
  
bio-sensing  
for an 'everyday life and field application', a minimal sensor setup is desired for comfort reasons.   
  
the monitoring belt consists of three smart fabric sensors to acquire cardiac activity, breathing rate and skin temperature (zephyr). the body acceleration is measured with a 3d accelerometer included in the recording device. in addition to ecg data, the chest belt provides rr intervals by measuring the duration between two consecutive r waves of the ecg.  
  
work package 3 - system development  
  
objectives  
  
creation of a complete textile system  
  
description of work  
  
task t 3.1 firefighter system  
in task 3.1 the specification, design, development and integration of all components belonging to the system used by the operational firefighters is carried out. this task includes the creation of early physical prototypes to investigate ergonomic options. the firefighter system also includes all augmented tools that might be carried by the firefighters such as the smart lifeline.  
  
results achieved in task  
  
fire fighter system  
  
computing unit  
  
following the results pres ...

# PROCOTEX

Project Acronym: PROCOTEX

programme & topic: FP7-PEOPLE FP7-PEOPLE-2009-IRSES

Most frequent returning words in objectives:

* ('electroless', 6)
* ('deposition', 6)
* ('textile', 5)
* ('transistor', 5)
* ('detection', 5)
* ('technologies', 4)
* ('formation', 4)
* ('developed', 4)
* ('textiles', 4)
* ('mpcs', 4)
* ('department', 4)
* ('procotex', 3)
* ('training', 3)
* ('researchers', 3)
* ('structures', 3)
* ('students', 3)
* ('on-off', 3)
* ('sensors', 3)
* ('technology', 3)
* ('layer', 3)
* ('sensitivity', 3)
* ('filtration', 3)
* ('university', 3)
* ('project', 2)

the project procotex aimed to provide training to early-stage and experienced researchers in three technologies being:   
  
 - electrospinning and nanofibres;   
 - coating of fibrous structures through electroless deposition of conductive polymers and metals;   
 - (electro)catalysis of metallophthalocyanines including its layers obtained through self-assembled monolayer (sam) formation.   
  
 based on the training provided in the first year, a number of prototype products were going to be developed in the second year. in fact three products were envisaged that should be the result of development using the three different technologies in which the students are trained.   
  
 1. textile fibre with transistor properties as on-off switch for textile sensors: on-off switching of textile sensors is of crucial importance. despite that textile sensors are constructed from textiles and are thus smoothly implemented in the textile structure, measurement and control means are not, among them on-off switches. therefore such switches are developed by using transistor technology. fibres are coated with a metal layer (metallic layer of the transistor) through electroless deposition, followed by coating with an insulating layer using dip-coating technology, followed by coating with a semiconductor and finally source and drain are added on top through electroless deposition. such architecture on a fibre mimics the transistor architecture of a flat transistor obtained at the surface of a film substrate.   
  
 2. sensor for nitric oxide (no) detection: no plays regulatory roles in physiological processes such as smooth muscle relaxation, anticoagulation and neurotransmission. direct detection of no in vivo is a necessity for studying its role in these physiological processes. no is unstable with a short half-life time of about 5 seconds, and it rapidly reacts with oxygen to form nitrite or nitrate ions. thus, methods for direct determination of no must be fast, and must show high selectivity and sensitivity. in our research, we use phthalocyanines as modifiers for electrodes used for no detection in order to improve on the sensitivity and selectivity of its detection. we developed this kind of electrodes before to monitor no injected into blood and released from rat brains. in procotex we will modify the electrode surfaces with nanofibres to increase specific surface area. this allows the immobilisation of a higher concentration of mpcs onto the same geometrical area with the result of improving sensitivity and detection limit.   
  
 3. filter for dedicated filtration of nox: proof of principle is given for the use of nanofibrous structures in air and liquid filtration. however, selective filtration towards nox would boost these types of filters to a higher technological and application level. in order to reach that position nanofibrous structures need to be modified with suitable mpcs that act as catalyst for nox oxidation and thus eliminate nox by oxidation.   
  
 the different technologies to be combined were brought together by the 3 partners, being:   
  
 - electrospinning, being offered by ugent, ghent university, department of textiles;   
 - electroless deposition, being ugent, ghent university, department of textiles and teipir, technological education institute of pireaus, department of textiles;   
 - mpcs and sam formation, being rhodes, rhodes university, department of chemistry.   
  
 each group developed a course to train the students and labs were established at the different partner institutions to allow access to all 3 technologies.   
  
 although the exchange of researchers was less executed as planned, most of the milestones and deliverables were reached. more important the procotex project resulted in:   
  
 - an efficient and deep training of a substantial number of students in electrospinning, electroless deposition, mpcs and sam formation;   
 - the establishment of electrospinning and electroless deposition labs;   
 - 12 direct and 6 indirect papers in high impact factor international journals;   
 - 1 workshop and 3 conference contributions;   
 - 1 patent application and a second one in preparation;   
 - the exchange of researchers allowing to bring mpc and mpc-sam formation technology to europe.

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# SURFUNCELL

Project Acronym: SURFUNCELL

programme & topic: FP7-NMP NMP-2007-2.1-1

Most frequent returning words in objectives:

* ('cellulose', 64)
* ('properties', 41)
* ('surface', 37)
* ('materials', 30)
* ('membrane', 27)
* ('nanoparticles', 22)
* ('chemical', 21)
* ('membranes', 21)
* ('nano-particles', 18)
* ('water', 18)
* ('polysaccharides', 17)
* ('surfaces', 17)
* ('matrix', 14)
* ('interaction', 13)
* ('polysaccharide', 13)
* ('production', 13)
* ('process', 12)
* ('fibres', 12)
* ('resistance', 12)
* ('project', 12)
* ('development', 12)
* ('demonstrators', 12)
* ('products', 11)
* ('layers', 10)

executive summary:  
1.1 executive summary  
polysaccharides produced by plants and microorganism are the most abundant biopolymers on earth. they are used by manly as low complex and low value products and their exceptional properties are mostly neglected. these biopolymers are multifunctional and stereoregular by nature, show a large variety of complex structures based on small chemical variations. this projects vision was to contribute knowledge how these specific properties can be utilized more effectively in order to transfer these biopolymers into high value products.  
the projects main rtd objective was to create new, smart and bio-based surface nanostructured polymer composites providing high value surface functionalities (mechanical, chemical, selective interaction properties). these new materials should be composed of nano-scaled polysaccharide layers with embedded nano-particles, for the coating of different cellulose matrices. the compounding is restricted to the biopolymers surface and outer layers, providing the 'filler'â to the domain where it is required and avoiding the deterioration of the matrix materials mechanical properties.  
a multidisciplinary team provided the needed complimentary know how. the integrative work program defined strategic routes towards new materials followed by up-scaling of some results into industrial pilot production. experimental investigations of the basic principles together with extended modelling have provided the necessary understanding to develop the technologically best candidates towards production. lca has provided decision making support to choose process routs environmentally acceptable for manufacturer and the society.  
finally 4 from the industrial partner envisaged products and two scientific hot topic were developed towards pilot production stages.  
the basic research provided new cellulose derivatives with specific functionalities, new synthetic routs for the save production of different kinds of nanoparticles and allowed to build up an extended know how to produce biobased nanostructured surface compounds.  
these innovative products comprise:  
- water purification membranes providing reduced fouling (elongated operating life time) and degradation of hormone residues present in drinking water via immobilized enzymes.  
- cellulose fibres with integrated and stable immobilized silver nanoparticles providing desired antimicrobial properties. these fibres will be integrated into fabrics used in hygienic, public and sports application.  
- cellulose based packaging material with improved water vapour barrier properties. cellulose packaging material replacing synthetic polymer packaging materials has low resistance against humidity permeation. non-renewable materials providing these barrier properties can be substituted by a barrier coating using natural compounds.  
- high-yield pulp office paper with same aging resistance and mechanical strength as conventional wood free office paper.  
- the scientific hot topics develop to demonstrator stages are both high tech cellulose based coatings; one amino cellulose coating for the immobilization of protein receptors and one cellulose coating for the structuring of micro-scaled channels for microfluidic devices and 3 dimensional structures using digital printing.  
  
project context and objectives:  
1.2 summary description of project context and objectives  
1.2.1 project concept and objectives  
polysaccharides produced by plants and microorganism are the most abundant biopolymers on earth. they are used by humans for many purposes beside nutrition. partially as they are provided by nature and partially derivatized and processed for different purposes as textile or technical fibers, membranes, packaging material and ingredients in food, cosmetics, toilet articles and pharmaceuticals. these biopolymers are multifunctional and stereoregular by nature, show a large variety of complex structures based on small variations of their chemical primary structure. beside all development made during decades we still make in general no use of their specific and often extraordinary properties. the projects vision was to contribute knowledge how these specific properties can be utilized more effectively in order to transfer these biopolymers into high value products.  
the projects main rtd objective was to create new, smart and bio-based surface nanostructured polymer composites providing high value surface functionalities (mechanical, chemical, selective interaction properties). these new materials should be composed of nano-scaled polysaccharide layers with embedded nano-particles, for the coating of different cellulose matrices. the compounding is restricted to the biopolymers surface and outer layers, providing the 'filler'â to the domain where it is required and avoiding the deterioration of the matrix materials mechanical properties.  
this has several major advantages: the filler is not compounded into the bulk material, the technical process of cellulose matrix production (films, membranes, fibers) can stay unchanged, the deterioration of the matrix materials mechanical properties is avoided and only small quantities of nano-particles are needed to gain the expected / desired effects.  
the project is based on new knowledge about the feasibility of coating a solid cellulose surface with soluble polysaccharides (ps) in an irreversible manner due to their chemical similarity offering the interaction by h-bridges and hydrophobic interactions. this is even the case with oppositely charged and derivatized ps as long as they do not have a significant amount of side chains. a further feasibility step proved that the incorporation of nano-particles into this layer is possible if certain conditions are obeyed. the projects target is the development of this strategic route into new materials and the up-scaling of some results into an industrial pilot production state. this comprised the study of these new effects (cellulose/polysaccharides dissolution, structuring with nano-particles and irreversible coating of cellulose matrices) with the aims of understanding and mastering them, the exploration of their properties and applicability and development of the most promising ones of the new materials a pilot scale production process. this concept opens several routes, each with many different applications, to prepare a completely new class of materials:  
  
nanostructured biopolymer surface composites made of  
polysaccharide - coated cellulose with embedded nano-particles  
  
the development of new, innovative biomass-based materials is of strategic importance. decreasing oil resources, the increase of the global warming and the awareness of european citizens of the need of more eco-friendly products are the major driving forces. the tremendous development of bio-based products, mainly materials and polymers in the third counties (asian, brazil) and in the usa, is driven by the wide, mainly unexplored or unknown, opportunities of developing new products by chemical manipulation of bio-based materials. if europe wishes to be competitive and develop its industry, creating wealth and jobs, it has to boost research that can be transformed into new products. this was the aim of our project which is fully in line with eu directives like the renewable energy roadmap, the biomass action plan or the environmental technology action plan.  
accordingly, this project aimed at the development of a new class of sustainable materials with substantially improved technological properties. several research and technology transfer tasks were defined comprising:  
- derivatize the coating polysaccharides to gain expected functionalities and to dissolve them at the molecular / nano level;  
- prepare and characterize stable dispersions of different kinds of nano-particles;  
- coat the solid cellulose matrix materials with nano-scaled polysaccharide layers;  
- integrate different kinds of nano-particles into this coating;  
- tune the interaction forces to achieve irreversible adsorption or controlled release;  
- generate a deep understanding for the involved physical and chemical processes using different modelling approaches;  
- characterize the properties of the new materials and compared to existing material;  
- scale up the most promising new materials and transfer into a pilot production stage;  
- prove the sustainability of the new materials by life cycle and economic analysis.  
the project brought together a multidisciplinary team in order to achieve this, each partner providing different and complimentary know how. it combined the team with the help of an integrated work program starting with fundamental research in order to prove the technological concept, and extend this from laboratory scale via a primary up-scaling into industrial demonstrator systems. experimental investigations of the basic principles together with extended modelling have provided the necessary understanding to extend it towards production. lca has provided decision making support to choose process routs environmentally acceptable for manufacturer and the society.  
1.2.2 formation of functionalised biobased polymer compounds using interface processes  
non-soluble polysaccharides, especially oriented moieties like cellulose, exhibit huge surface areas. this creates conditions for strong physical interactions (lewis acid based interactions and van der waals forces) with chemically similar compounds. as a consequence, many naturally occurring polysaccharides (ps) adsorb more or less irreversibly on cellulose surfaces. it is also possible to dissolve chemically modified/functionalised ps and to adsorb them from solution irreversibly on a cellulose matrix, providing surface functionalized materials with new mechanical properties. in an additional step a wide variety of nanoparticles can be embedded into this coating layer.  
first step is the functionalization of dissolved ps, followed by deposition of a cellulose surface and embedding of nano-particles into this film. in an alternative process rout the nano-particles interact first with the functionalized ps and this assembly is afterwards adsorbed on the cellulose surface. the strong interaction between the adsorbed ps coating and the cellulose matrix is responsible for the irreversible surface treatment.  
one key feature of the developed method is, that a wide range of materials can be prepared, opening the way to new functionalized composite materials in an area where so far only a small range of possibilities have been envisaged. examples of property enhancement are:  
- selective interaction possibilities;  
- improved mechanical, chemical and thermal stability, barrier properties;  
- surfaces providing a controlled release of active substances;  
- surfaces showing tunable properties;  
- catalytic properties based on renewable materials;  
- selective sensor surface;  
- biocompatible medical devices.  
  
the second key feature is that many desired surfaces properties are achievable using sustainable and environmental friendly processing routes turning renewable materials into high-value goods.  
the final processing happens exclusively in heterogeneous reaction systems where surface area and interfacial processes play a dominant role. the understanding of physical interactions acting in this heterogeneous systems consisting of functional compounds (soluble polysaccharides, polyelectrolytes, surfactants, pigments and nano-particles) and the macroscopic cellulosic matrix material was improved and the processes finally utilized technologically. the reasons for the processes complexity are the diversity and limited and inherent micro-heterogeneity of natural polysaccharides. therefor the derivatisation, modification and processing of ps is often difficult and nano-scale structuring is especially complicated. this is to a large extent the reason why more advanced polymer technology is almost exclusively based on petrochemistry.  
the transformation of natural polymers, presently used mainly in low-cost, low-added value commodities, into economically and ecologically sustainable high-tech, high added value products is a challenge. our project provided several ways to achieve this (figure 1):  
- deposition of chemically modified/ specifically functionalized polysaccharides in (structured) nano-layers on the surface of cellulose matrices (foils, membranes, fibres). the irreversible adsorption of these layers on cellulose is due to their chemical similarity, resulting in the possibility of hydrogen bonding and hydrophobic interactions.  
- incorporation of nano-particles into this surface layer in two ways:  
- dispersion of the nano-particles into polysaccharide solutions and deposition of the formed aggregates onto the cellulose matrix.  
- deposition into the already formed polysaccharide surface layer.  
  
these processing routes are finishing treatments of already shaped renewable polymers rendering them into high-value goods. preferably aqueous solvents and environmentally friendly processes are employed. modifications of the matrix materials production conditions are not be necessary. this strategy opened several ways to create new classes of bio materials with tailored functions and properties applicable in the following fields:  
- separation technology: materials with selective interaction properties (with organic, inorganic and biological compounds), tunable by environmental conditions.  
- technical fibres and foils: specific surface modification (strength, abrasion resistance, thermal and chemical stability, hydrophilicity/hydrophobicity 'â¦).  
- improved material properties: flame resistance, conductivity, antimicrobial activity, barrier properties.  
- medical and hygienic devices: controlled release of drugs, antimicrobial compounds.  
- biosensors, displays, electronic devices: devices that change structurally under the influence of an external field, and visionary but not impossible, preparation of semiconducting devices on fibre surfaces.  
  
project results:  
1.3.1 targets/demonstrators defined by industrial partners  
innovia's demonstrators:  
- moisture barrier of <30 g/m2/day measured at 38â°c and 90% rh.  
- heat seal strength of >200g/25mm which are maintained under moist conditions.  
  
litija's demonstrators:  
surface modification of viscose fibres applying nano-particles in a wet finishing process. the new high-value viscose fibres have to be mechanically and chemically resistant to all mechanical and chemical textile processing and should possess the following properties:  
- anti-microbial treatment (bacterial reduction of more than 95%).  
- protection against uv irradiation.  
  
mondi's demonstrators:  
office papers with enhanced optical properties, which are defined as following:  
- high-yield pulp office paper with same aging resistance and mechanical strength as conventional wood free office paper.  
- 20% reduction of yellowing after 500 w irradiation by xenon lamp.  
- 75 g/m2 office paper with same opacity as conventional 80 g/m2 office paper.  
- increase of mechanical strength significantly (tear resistance and stiffness) by 10%.  
  
x-flow's demonstrators:  
ultra filtration membranes for surface water treatment to reject:  
- selective removal of endocrine materials from urine (hormones from anti baby pill, dna, rna, protein fractions). concentrations of endocrine disruptors and other micropollutants are demanded by regulations to be at 5 ppb or even 1 ppb.  
- nom (natural organic matter) ranging from molecular weights of roughly 100-1000 da and from hydrophilic to hydrophobic nature.  
  
scientific hot topic demonstrators:  
partner 4 (university jena) has developed amino cellulose surface coatings building self-assembled monolayers with excellent properties for enzyme immobilization.  
  
the project has generated ways to create new, nano-structured materials with specific functionalities based on renewable polymers. the envisioned surface modifications were achieved applying interaction processes without heavy chemistry:  
- incorporation of specific anionic or cationic groups (for selective interactions);  
- introduction of antimicrobial groups;  
- introduction of specific adsorption sites or groups (dna fragments, protein receptors);  
- introduction of specific surface properties such as hydrophobicity, low surface energy, barrier properties via layer by layer structures (water vapor, oxygen barriers);  
- the possibility to create cationic, non-charged and anionic membrane surfaces depositing likely charged polysaccharides on a cellulose membrane surface.  
  
specific nano particles were embedded into the polysaccharide coating to achieve:  
- antimicrobial activity (ag, cu, zno, ag, pt particles) ;  
- optical properties (tio2, zno, silica nanoparticles);  
- flame retardency (layered silicates, clay nanocomposites);  
- catalytic devices.  
  
in order to improve the understanding and enlarge the material basic for the demonstrators a variety of ps derivatives and stabilized nanoparticle were synthesized and combinations of both, the ps functionalities and nano ' particles was prepared. these combinations had all together the common ground of similar chemical and physical basic processes and technologies.  
together with the industrial partners the technologically promising combinations were defined at the project stage 'final selection of topics'â, focused on the 4 main targets (demonstrators), see figure 3. due to the fact that numerous approaches were possible, a very restrictive selection process was needed to focus on the defined targets. the selection criteria were defined in accordance with the industrial partners. criteria were a combination of the propability to reach the technological goals (risk of technology failure and unexpected problems), market size, commercial benefits and estimated time to market as well as environmental aspects defined by lca. the target was to bring these demonstrators towards a pilot scale production and application.  
in addition, beside these technologically very demanding but realistically achievable targets we defined that additional visionary target(s) not in the industries primary focus but of demanding scientific and technological properties with future industrial applications might also be developed.  
1.3.2 project organization  
the research and development activities were organized (figure 4) in the following work packages:  
- wp1: chemical functionalisation of ps.  
- wp2: nano-paticle systems: creation, dispersion, characterisation and interaction with dissolved polysaccharides.  
- wp3: interaction of functionalised ps with cellulose matrix and embedding of nano-particles into/onto ps coated cellulose matrices.  
- wp4: development of surface functionalisation of films and membranes.  
- wp5: development of surface functionalised fibres and non wovens.  
- wp6: life cycle assessment.  
- wp7: management.  
- wp8: dissemination.  
  
1.3.3 s&t results  
1.3.3.1 wp1: chemical functionalization of ps  
objectives  
1. dissolution of cellulose and other polysaccharides in different solvents as well as characterisation of the solutions obtained.  
2. chemical and physical functionalization of cellulose and other polysaccharides.  
3. transfer into the pilot scale.  
  
tasks  
1. dissolution of cellulose and other polysaccharides in different solvents, solution characterization and properties. goal was to prepare, to characterize and to understand cellulose-starch mixtures in ionic liquid in the fluid and solid state.  
2. synthesis of polysaccharide derivatives with different functional groups, degree of substitution and partially region-selective derivatisation.  
3. synthesis of cationically charged cellulose moieties and coating on polysaccharide to improving the binding properties of antibody-proteins on surfaces (e.g. glass).  
4. scale up of new functionalized cellulose moieties.  
  
significant results  
- cellulose and starch coexist without any phase separation in emimac as far as total polymer concentration used is far from their dissolution limit. cellulose- and cellulose/starch hybrid-films were prepared using ionic liquids as solvent. the starch was found to be inhomogeneously distributed in the hybrid-films. their permeability dropped with pressure increase.  
- several new cellulose derivatives providing different functionalities were synthesized with degree of substitution and regio-selectivity.  
- cellulose-iâ?-lipoate sulphate was found to stabilize gold nanoparticles. single hollow fiber modules provided by x-flow have been coated with 6-deoxy-6-azido/aminopropargyl-carboxymethyl cellulose ' evaluation at x-flow revealed significant loss of permeability.  
- the binding of proteins on glass and polymer surfaces was improved using cationically charged cellulose moieties. after the successful antibody immobilization on the amino cellulose modified layer, these layers were used for a real-time crp (antigen) detector system.  
- scaled up products of specific polysaccharide compounds are available.  
1.3.3.2 wp2: nano-paticle systems: creation, dispersion, characterisation and interaction with dissolved polysaccharides  
objectives:  
1. synthesis of metal, metal oxide and semiconductor nanoparticles.  
2. adjustment of the nanoparticle chemical composition, size, shape and dispersity.  
3. optimisation of nanoparticle physical properties for individual demonstrators.  
4. preparation of stable nanoparticle dispersions in dissolved ps and derivatised ps.  
5. optimisation of nanoparticle porosity in terms of nanopores and pore size dispersity.  
6. study of dispersed nanoparticles interactions with cellulose and ps (modified/raw).  
7. development of robust models of real nanoparticle-polysaccharide interactions.  
  
tasks and participating partners  
1. in-situ preparation of stable tio2 (tio2/sio2) ' cellulose derivatives colloidal solutions and preparation procedure optimisation for in-situ deposition on cellulose surfaces (p5).  
2. synthesis of ag-cellulose derivative nanocomposites for antimicrobial fibres (p1, p2).  
3. nobel nanoparticles for hormone removal (p5, p8, p9).  
4. preparation of aqueous nanoparticle suspensions in larger scale (p8).  
5. enhancement of understanding of the nanoparticles dispersion process in cellulose solutions and preparation of cellulose acetate nanoparticles (p1, p3).  
  
significant results  
- the process to stabilise aqueous dispersions of tio2, ag and metal nanoparticles using water-soluble polysaccharides was optimised. polysaccharides can be used as reducing agents as well as stabilisers at low temperatures in cost-effective, environmentally friendly reactions. these dispersions of porous nanoparticle/ps nanocomposites are stable at room temperature for many months and sometimes for more than one and a half years.  
- new synthetic methods to prepare colourless ag nanoparticles and in situ ag nanoparticles using microwave irradiation were developed and used for litija's demonstrators to produce fibres with significant antibacterial properties against resistant bacteria, such as mrsa, found in hospital environments, for example. the size and shape of the nanoparticles could be controlled from very small (app. 10 nm) to very large (app. 600 nm).  
- microporous pentair x-flow membrane wp4 demonstrators coated with ps-stabilised ag nanoparticles from aqueous colloidal solutions showed significant antibacterial activity for water remediation.  
- an environmentally friendly microwave synthesis of ag nanoparticles in aqueous solution was developed, whereby the synthesis reaction time was reduced by factor of 60.  
- a route to synthesize cellulose acetate nanoparticles with different surface functionalities was developed  
- an environmentally friendly zno nanoparticle method of preparation in aqueous solvents was successfully up scaled. these platelets have been used for litija's demonstrators to produce fibres with significant antibacterial properties.  
- reduction of the undesired tio2 photocatalytic activity was achieved by coating the nanoparticle with aptes.  
- core/shell titania/silica nanoparticles were prepared and deposited using a layer-by-layer approach on mondi's demonstrator paper that became whiter, brighter and more stable to degradation by sunlight.  
- preparation of carbon black sub-micro particles in aqueous cellulose solutions. microporous membranes (x-flow demonstrator) coated with pd-stabilised ag nanoparticles from aqueous colloidal solutions showed significant heterogeneous catalytic activity for continuous-flow reactions in water.  
1.3.3.3 wp3: interaction of functionalised ps with cellulose matrix and embedding of nano-particles into/onto ps coated cellulose matrices  
objectives  
1. preparation, characterization and activation of reference matrix materials (cellulose, films, fibres, membranes).  
2. adsorption-desorption of dissolved derivatised cell and ps (modified and raw) on cellulose matrices.  
3. embedding/immobilisation of nano-particles on original and coated cell surfaces.  
4. characterisation of cell ' nano-particles compounds.  
5. modelling of the adsorption-desorption process.  
6. transfer into small scale pilot scale.  
7. scientific hot topic ' microfluidic protein detection system.  
  
tasks  
1. study of adsorption of polysaccharide stabilised nanoparticles on cellulose model films and real surfaces.  
2. antifouling / antimicrobial coatings on membrane substrates.  
3. model coating development to improve barrier properties.  
4. scientific hot topic ' microfluidic protein detection system.  
5. cellulose matrix pre-treatment and in situ formation of ag nanoparticles.  
6. modelling of adsorption process in molecular and micrometer scale.  
  
significant results  
- general know-how according the np adsorption process, its dependence on ionic strength, ph and np stabilisation agents.  
- coating formulation of inorganic oxide particles (i.e. tio2), prepared in a solution of a polysaccharide (i.e. cmc), can serve as an efficient modifying agent, with which new properties and functionalities can be imparted to different cellulose matrices.  
- it is the dispersing and stabilizing ability of a cellulose derivative solution that ensures the maximum effect provided from active particles ' insufficient stabilization would inhibit their activity. in addition to that, stable polysaccharide-based particles' dispersions act as a carrier and adsorbing driver for homogenous deposition of inorganic particulate matter on surface of various cellulose substrates.  
- activation of cellulose fibres for enhanced particle synthesis and formation of firmly-attached coatings.  
- in situ preparation of ag nanoparticles on fibre surfaces causes strong deposition withstanding several washing procedures.  
- molecular modelling of the cellulose surface, their interaction with water molecules and oligosaccharides using semi-empirical and ab initio methods.  
1.3.3.4 wp4: development of surface functionalisation of films and membranes  
the demonstrator deliverables in wp4 are twofold and are partner specific. the deliverables for x-flow bv have been achieved and not only substantially surpassed are somewhat in advance of that expected at this point in time.  
the deliverables for innovia films were finally also achieved. more effort was needed due to the need to produce model films with consistent properties that enables the transfer of the laboratory work achieved in wp2 and wp3. a pilot plant production of cellophane films with increased hydrophobicity and decreased water vapour transmission was obtained.  
  
cellulose acetate hollow fibre membranes with antimicrobial coating and enzymatic hormone degradation  
x-flow hollow fibre standard membranes were coated with hydrophilic silver containing sol-gel material. the permeability of clean water was investigated with flow tests. the morphology and elemental composition of the coated membranes was investigated with scanning electron microscopy (sem) and energy dispersive x-ray spectroscopy (edx).  
the chemical stability of the coated membranes against sodium hypochlorite cleaning was investigated. in addition long term filtration experiments with surface water were performed. edx and sem measurements revealed a successful immobilisation of silver in the membrane structure (figure 23). long term filtration tests showed that low amounts of ag have no negative effect on the life time of the membrane.  
up-scaling on fibre modules (rx300 modules) of the in situ coatings with silver was performed (figure 24). again sem, edx and flow tests were performed; the chemical resistance was investigated by a sodium hypochlorite treatment.  
it could be shown that in situ coating with silver reduces the clean water permeability of fibre modules. also the chemical stability is reduced when silver is present in the membrane. nevertheless silver was successfully immobilised inside the membrane structure. therefore the silver has a potential application as antimicrobial coating.  
cellulose acetate hollow fibre membranes were successfully coated with sio2. edx studies revealed the presence of silicon over the entire membrane structure. flow tests with clean water showed a reduction of the permeability even though no changes in the pores size of the membrane could be observed.  
cellulose acetate hollow fibre membranes were successfully coated with sio2. edx studies revealed the presence of silicon over the entire membrane structure. flow tests with clean water showed a reduction of the permeability even though no changes in the pores size of the membrane could be observed.  
for the increase in hydrophilicity and improvement of anti-fouling properties, model surfaces of cellulose acetate and single hollow fibre membranes were coated with multi-layers of chitosan and carboxymethyl cellulose. the controlled release of the multi-layers for a cleaning of membranes was investigated. multi-layer growth and controlled release were evaluated by optical thickness; contact angle measurements atomic force microscopy and scanning electron microscopy.  
the polysaccharide multi-layer built up could be controlled with the ph value of the coating solutions. in general, thicker layers are produced at lower ph values. layers with a thickness of several hundred nanometres can be obtained. a successful removal of these coatings can be performed under defined washing conditions. this opens the way to generate anti-fouling coatings which can be regenerated.  
further investigations on the coating conditions of membranes are necessary. the long term anti-fouling properties of the membranes with surface water are under investigation. for testing the antimicrobial activity of surfaces, a combination of methods was developed. electron microscopy, fluorescence microscopy and real time pcr were successfully combined to investigate bacterial growth on surfaces. chitosan/cmc coatings on cellulose acetate surfaces turned out to be very efficient in inhibiting bacterial growth. these coatings are therefore used to create anti-fouling layers on cellulose acetate surfaces.  
for the enzymatic digestion of endocrine compounds horse radish peroxidase enzymes were successfully isolated from pichia pastoris fermentation cultures. purification was performed with anion exchange and size exclusion chromatography. pure enzymes with high activities and the ability to digest estrogens were obtained. those enzymes are covalently immobilized on layer coated ca membranes and are tested using medium sized pilot membrane modules.  
figure 25 shows the resistance of the membrane versus the filtration time of real surface water at the twente canal in the area of enschede. the surface water is still standing canal water, which has a high organic load. the high organic load mostly fouls the membrane dramatically and is therefore a good indication if a low fouling membrane is present or not.  
the graph shows that our standard membrane (blue line) starts similar to the in-situ ag coated membranes. this also indicates that the permeability (resistance) did not change after coating the ag on the membrane. during filtration time, fouling is built up on top of the membrane and with that the resistance of the membrane increases. the standard membrane lies slightly higher than the coated membrane, which indicates that the coated membrane fouls slightly less than the standard membrane. this trend can also be seen after a first chemical backwash, where all the fouling material is removed from the membrane and the resistance is going back to zero. also after all other chemical backwashes, the coated membrane stays below the resistance of the standard type of membrane.  
the production of large cellulose acetate and cellulose acetate butyrate flow modules was performed (figure 26). the influence of the wall thickne ...

# FIBRE

Project Acronym: FIBRE

programme & topic: FP7-PEOPLE FP7-PEOPLE-IEF-2008

Most frequent returning words in objectives:

* ('fibre', 21)
* ('textile', 13)
* ('sheep', 8)
* ('fibres', 7)
* ('development', 7)
* ('italy', 7)
* ('wool', 7)
* ('changes', 7)
* ('ancient', 6)
* ('production', 6)
* ('data', 6)
* ('analysis', 6)
* ('project', 5)
* ('roman', 5)
* ('materials', 4)
* ('processing', 4)
* ('period', 4)
* ('textiles', 4)
* ('bronze', 4)
* ('iron', 4)
* ('material', 3)
* ('sources', 3)
* ('qualities', 3)
* ('standardisation', 3)

throughout history, textile manufacture was practiced on all levels of society and was one of the most labour intensive of all occupations. as such, it was an industry of great cultural and social importance and should be factored into any balanced assessment of the ancient economy. this includes not only processes such as spinning and weaving but the entire operational sequence of textile production, particularly the acquisition of raw materials. after all, textile quality and appearance are dependent on the material of which the textile has been made, i.e. on fibre. fibre investigation, hence, is more than just identification of material source. by studying fibre on a microscopic and even molecular level we can come closer to understanding issues of selective breeding and cultivation, processing of fibres and their wear.   
  
 the fibre project investigated the development and use of textile fibres in italy from prehistory to the roman period through an integrated study of archaeological textiles, archaeozoological and archaeobotanical data, as well as of ancient written and iconographic sources. the specific objectives of the fibre project were:   
 1. to elucidate endogenous developments of textile fibres in ancient italy and their spread throughout europe and the mediterranean area;   
 2. to evaluate the old and develop new fibre analytical methods and ways of interpreting the obtained data;   
 3. to integrate fibre studies into interdisciplinary research of broader archaeological interest.   
  
 ancient literary sources indicated that, by the beginning of the common era, different qualities of wool and flax were available to roman consumers and many of the best fibres were produced in italy, from where they spread throughout the roman empire in the form of sheep, raw materials or finished textiles. the standardisation of fibre observed during the roman period reflected a long period of evolution, based on the selection and development of processing technologies.   
  
 the systematic collection of data and analysis of over 60 fibre samples obtained from archaeological textiles found in italy and dating from the middle bronze age, circa 1 600 bc, to the roman period, i.e. 1st century ac, suggested that major changes in textile fibre development took place in the apennine peninsula sometime around the turn from the bronze age to the early iron age. flax plants became taller and their fibres became slightly thicker as well as more uniform and therefore less susceptible to breaking, allowing for more industrialised forms of processing. the changes in sheep fleece demonstrated the development of primitive wool with very fine underwool and very coarse kemps, as well as the progressive disappearance of kemps and the evolution of slightly coarser but much more uniform fleeces, as demonstrated by the average fibre diameter and range. the fibre analysis along with the palaeoproteomic data also suggested that, during the first millennium bc, several distinct wool qualities coexisted, possibly reflecting the use of several sheep breeds for fibre acquisition.   
  
 the methodology of wool fibre quality analysis was reviewed, concluding that, while the measurement method was sound, a much more nuanced approach in the interpretation would allow for a finer classification of prehistoric wools. a recently developed fibre provenancing method of strontium isotopic tracing was applied to the italian archaeological material for the first time. deoxyribonucleic acid (dna) analysis and the newly developed palaeoproteomics approach were applied to the selected set of samples. these methods not only served as independent checks of species identification but also promised to be useful in addressing the questions of specific sheep breeds and, consequently, fibre and textile qualities, particularly when correlated with wool fibre analysis.   
  
 changes in wool production were also archaeologically traced through sheep bone assemblages, whose analysis pointed towards an increasing importance of ovicaprids from the middle bronze age to the early iron age. even more significant were the mortality data which indicated that, starting in the early iron age, sheep were increasingly kept for wool, as shown by the large number of old animals that were present in the assemblages. the increase in sheep bone percentages correlated with the large numbers of textile tools found on settlement sites in pre-roman italy and with their standardisation, corresponding to the intensification of textile making activities and a demand for the appropriate equipment.   
  
 the project demonstrated the potential of archaeological fibre for the investigation of ancient economy, technology and agriculture and for answering some of the fundamental questions of archaeology, where evidence for textiles and fibres was hitherto virtually unexplored. thus, changes in textile fibres of ancient italy illustrated important developments in sheep domestication and breeding, which could not be gleaned from other sources, and revealed the socioeconomic impact of textile raw materials. the fact that these changes happened during the transition from the bronze age to the iron age pointed to the development of new or more effective production processes, standardisation and manufacture of objects for specific purposes. these changes also corresponded to the development of highly stratified societies and large urban centres, which created a demand for organised and specialised production of goods. the qualitative changes in textile production were also reflected in the development of better raw materials, which allowed for faster processing and production, as well as for more complex techniques and patterns. the integration of fibre data obtained during the fibre project with information published for other european areas, e.g. greece, austria and switzerland, indicated that, even though similarities existed, fibre evolution in italy followed its own path.   
  
 further information regarding the project could be provided via the http://www.ucl.ac.uk/archaeology/people/staff/gleba website or through emailing m.gleba@ucl.as.uk.

# FIBRE

Project Acronym: FIBRE

programme & topic: FP7-PEOPLE FP7-PEOPLE-IEF-2008

Most frequent returning words in objectives:

* ('fibre', 21)
* ('textile', 13)
* ('sheep', 8)
* ('fibres', 7)
* ('development', 7)
* ('italy', 7)
* ('wool', 7)
* ('changes', 7)
* ('ancient', 6)
* ('production', 6)
* ('data', 6)
* ('analysis', 6)
* ('project', 5)
* ('roman', 5)
* ('materials', 4)
* ('processing', 4)
* ('period', 4)
* ('textiles', 4)
* ('bronze', 4)
* ('iron', 4)
* ('material', 3)
* ('sources', 3)
* ('qualities', 3)
* ('standardisation', 3)

throughout history, textile manufacture was practiced on all levels of society and was one of the most labour intensive of all occupations. as such, it was an industry of great cultural and social importance and should be factored into any balanced assessment of the ancient economy. this includes not only processes such as spinning and weaving but the entire operational sequence of textile production, particularly the acquisition of raw materials. after all, textile quality and appearance are dependent on the material of which the textile has been made, i.e. on fibre. fibre investigation, hence, is more than just identification of material source. by studying fibre on a microscopic and even molecular level we can come closer to understanding issues of selective breeding and cultivation, processing of fibres and their wear.   
  
 the fibre project investigated the development and use of textile fibres in italy from prehistory to the roman period through an integrated study of archaeological textiles, archaeozoological and archaeobotanical data, as well as of ancient written and iconographic sources. the specific objectives of the fibre project were:   
 1. to elucidate endogenous developments of textile fibres in ancient italy and their spread throughout europe and the mediterranean area;   
 2. to evaluate the old and develop new fibre analytical methods and ways of interpreting the obtained data;   
 3. to integrate fibre studies into interdisciplinary research of broader archaeological interest.   
  
 ancient literary sources indicated that, by the beginning of the common era, different qualities of wool and flax were available to roman consumers and many of the best fibres were produced in italy, from where they spread throughout the roman empire in the form of sheep, raw materials or finished textiles. the standardisation of fibre observed during the roman period reflected a long period of evolution, based on the selection and development of processing technologies.   
  
 the systematic collection of data and analysis of over 60 fibre samples obtained from archaeological textiles found in italy and dating from the middle bronze age, circa 1 600 bc, to the roman period, i.e. 1st century ac, suggested that major changes in textile fibre development took place in the apennine peninsula sometime around the turn from the bronze age to the early iron age. flax plants became taller and their fibres became slightly thicker as well as more uniform and therefore less susceptible to breaking, allowing for more industrialised forms of processing. the changes in sheep fleece demonstrated the development of primitive wool with very fine underwool and very coarse kemps, as well as the progressive disappearance of kemps and the evolution of slightly coarser but much more uniform fleeces, as demonstrated by the average fibre diameter and range. the fibre analysis along with the palaeoproteomic data also suggested that, during the first millennium bc, several distinct wool qualities coexisted, possibly reflecting the use of several sheep breeds for fibre acquisition.   
  
 the methodology of wool fibre quality analysis was reviewed, concluding that, while the measurement method was sound, a much more nuanced approach in the interpretation would allow for a finer classification of prehistoric wools. a recently developed fibre provenancing method of strontium isotopic tracing was applied to the italian archaeological material for the first time. deoxyribonucleic acid (dna) analysis and the newly developed palaeoproteomics approach were applied to the selected set of samples. these methods not only served as independent checks of species identification but also promised to be useful in addressing the questions of specific sheep breeds and, consequently, fibre and textile qualities, particularly when correlated with wool fibre analysis.   
  
 changes in wool production were also archaeologically traced through sheep bone assemblages, whose analysis pointed towards an increasing importance of ovicaprids from the middle bronze age to the early iron age. even more significant were the mortality data which indicated that, starting in the early iron age, sheep were increasingly kept for wool, as shown by the large number of old animals that were present in the assemblages. the increase in sheep bone percentages correlated with the large numbers of textile tools found on settlement sites in pre-roman italy and with their standardisation, corresponding to the intensification of textile making activities and a demand for the appropriate equipment.   
  
 the project demonstrated the potential of archaeological fibre for the investigation of ancient economy, technology and agriculture and for answering some of the fundamental questions of archaeology, where evidence for textiles and fibres was hitherto virtually unexplored. thus, changes in textile fibres of ancient italy illustrated important developments in sheep domestication and breeding, which could not be gleaned from other sources, and revealed the socioeconomic impact of textile raw materials. the fact that these changes happened during the transition from the bronze age to the iron age pointed to the development of new or more effective production processes, standardisation and manufacture of objects for specific purposes. these changes also corresponded to the development of highly stratified societies and large urban centres, which created a demand for organised and specialised production of goods. the qualitative changes in textile production were also reflected in the development of better raw materials, which allowed for faster processing and production, as well as for more complex techniques and patterns. the integration of fibre data obtained during the fibre project with information published for other european areas, e.g. greece, austria and switzerland, indicated that, even though similarities existed, fibre evolution in italy followed its own path.   
  
 further information regarding the project could be provided via the http://www.ucl.ac.uk/archaeology/people/staff/gleba website or through emailing m.gleba@ucl.as.uk.

# FIBRE

Project Acronym: FIBRE

programme & topic: FP7-PEOPLE FP7-PEOPLE-IEF-2008

Most frequent returning words in objectives:

* ('fibre', 21)
* ('textile', 13)
* ('sheep', 8)
* ('fibres', 7)
* ('development', 7)
* ('italy', 7)
* ('wool', 7)
* ('changes', 7)
* ('ancient', 6)
* ('production', 6)
* ('data', 6)
* ('analysis', 6)
* ('project', 5)
* ('roman', 5)
* ('materials', 4)
* ('processing', 4)
* ('period', 4)
* ('textiles', 4)
* ('bronze', 4)
* ('iron', 4)
* ('material', 3)
* ('sources', 3)
* ('qualities', 3)
* ('standardisation', 3)

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# ANAGENNISI

Project Acronym: ANAGENNISI

programme & topic: FP7-ENVIRONMENT ENV.2013.6.3-1

Most frequent returning words in objectives:

* ('concrete', 10)
* ('fibres', 9)
* ('steel', 7)
* ('tyre', 6)
* ('strength', 5)
* ('rubber', 4)
* ('results', 4)
* ('cruc', 4)
* ('reinforcement', 3)
* ('applications', 3)
* ('energy', 3)
* ('materials', 3)
* ('developed', 3)
* ('compressive', 3)
* ('tests', 3)
* ('shrinkage', 3)
* ('rtsf', 3)
* ('projects', 3)
* ('tyres', 2)
* ('year', 2)
* ('countries', 2)
* ('wire', 2)
* ('textile', 2)
* ('grade', 2)

executive summary:  
around one billion tyres are discarded each year, with post-consumer tyre arisings for eu countries alone exceeding 3m tonnes per year. tyres comprise roughly 80% rubber, 15% steel wire and 5% textile reinforcement by mass. nearly 50% of all recycled tyres/components end up as fuel, in low grade applications or in landfill. less than 25% of the energy required to produce rubber is recovered by incineration. all tyre constituents (rubber, high strength steel cord and wire, high strength textile reinforcement) are high quality materials and the aim of anagennisi was to recycle them as reinforcement in structural concrete applications. for that purpose, all materials were cleaned, sorted and classified using standardised or novel techniques developed during the project.  
rubber particles were used to substitute conventional aggregates in plain concrete (up to 60% total aggregate replacement) which results in severe loss in compressive strength, but increase in lateral strain. to regain the compressive strength, rubberised concrete (ruc) was confined with aramid frp jackets and the results showed compressive strengths up to 90 mpa and, more significantly, axial deformations up to 6% (normal concrete 0.2%). this high deformability can be utilised in seismic and other applications. the seismic performance of rc medium and large scale piers was assessed using afrp confined ruc (cruc) in targeted regions of the piers. the results showed that afrp cruc improved the energy dissipation up to 50% and increased ductility up to 25% - (compared to ruc). successful shake table tests were also conducted on buildings with cruc elements and base isolation columns. based on material tests, numerical models were developed to predict the short-term structural behaviour as well as the free shrinkage and creep deformations of ruc and cruc.  
recycled tyre steel fibres (rtsf) can partially replace manufactured steel fibres to increase the flexural strength of concrete â saving on virgin materials and reducing energy input requirements by 97%. rtsf fibres are shorter and much thinner than manufactured steel fibres, helping to control cracks at the micro and meso level. extensive tests on the flexural behaviour of rtsf reinforced concrete showed that fibre blends (with manufactured steel fibres) result in optimum mechanical characteristics, outperforming each fibre type on its own. steel fibres do not have a significant impact on free shrinkage, but help prevent or control cracking under restrained conditions. no cracking was observed after a period of 9 months for restrained specimens with 50% restraint.  
recycled tyre polymer fibres (rtpf) were easy to integrate in mortar and concrete easy using novel integration methods. the results show that they can decrease initial plastic and autogenous shrinkage and can potentially substitute virgin polypropylene fibres. rtpf reinforced concrete showed remarkable resistance to spalling when subjected to elevated temperatures, confirming the potential of these fibres for fire-induced concrete spalling mitigation.  
several demonstration projects were undertaken in five european countries to convince contractors and infrastructure owners of the benefits of the examined tyre by-products. these projects included slabs on grade, tunnel linings, precast concrete elements (rubberised poles and railway sleepers) and a repair screed application. design recommendations and examples were developed for all three tyre constituents. work was undertaken on the environmental (lca) and cost (lcca) life cycle assessment of the aforementioned demonstration projects to demonstrate the potential benefits.  
  
list of websites:  
www.anagennisi.org  
  
professor kypros pilakoutas   
e-mail: k.pilakoutas@sheffield.ac.uk  
tel.: +44 114 22 25065

# ANAGENNISI

Project Acronym: ANAGENNISI

programme & topic: FP7-ENVIRONMENT ENV.2013.6.3-1

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# Emperor

Project Acronym: Emperor

programme & topic: FP7-PEOPLE FP7-PEOPLE-2012-IEF

Most frequent returning words in objectives:

* ('status', 13)
* ('garments', 12)
* ('emperors', 11)
* ('project', 10)
* ('representation', 10)
* ('clothing', 10)
* ('roman', 8)
* ('texts', 8)
* ('silk', 8)
* ('emperor', 7)
* ('toga', 7)
* ('color', 7)
* ('century', 6)
* ('dress', 6)
* ('research', 6)
* ('statues', 6)
* ('sources', 5)
* ('elite', 5)
* ('garment', 5)
* ('article', 5)
* ('purple', 4)
* ('material', 4)
* ('show', 4)
* ('trade', 4)

project: the emperorâs new clothes. power dressing in the roman empire from augustus to honorius.  
  
this project explored changes in the costume of the roman emperor, his family and his court. the hypothesis was that we can track the development of an imperial wardrobe, which follows the gradual acceptance and consolidation of autocracy, from the plain woolen toga of the ideal first century ce princeps to the luxurious purple silks of the later imperial monarch. the aim was to highlight the continuities and breaks as well as the idiosyncrasies that occurred during this process by taking into account written as well as archaeological sources (like ancient textiles and visual material).  
in terms of status representation, the early roman emperors walked a tight rope between conforming to the supposed frugality and uniformity of their ancestors and being the rulers of the roman world. for historical reasons they had to avoid allusions to monarchy and behave as "first among equals" in their interaction with their senatorial peers. changes in status display through clothes therefore mirror, it is argued, the changing perception of the position of the emperor within the social hierarchy.  
the project covered the time from the first princeps, augustus, to the emperor honorius (1st century bce-5th century ce). in particular it focused on the representation of "good" vs. "bad" emperors as the discourses surrounding them are highly ideologically charged. one question was whether it is possible to define turning point(s) when the costume discourses changed and also âgoodâ emperors were allowed to represent their status visually through precious clothing. further: was this an indication that the position of the emperor at the top of the social hierarchy was now openly acknowledged and their corresponding status representation considered appropriate? thus this study of imperial dress and representation has aimed at shedding new light on the political and institutional history of the roman empire.  
in the course of the project, written sources as well as (mainly sculptural) depictions of emperors have been analyzed. two of the main results are:   
1. the messages and statements vary greatly, depending on the kind of source,   
2. the contents of the messages remain very consistent within one kind of source, even over centuries.   
for example: the highly moralizing literary texts written by the senatorial elite give the impression of an elite that is clinging to traditional clothing (like the large, semicircular piece of garment that men wrapped around their body, the so-called toga) until the 4th century ce. according to these texts, only the âbad emperorsâ are prone to display outlandish clothing, garments that are often simultaneously characterized as barbarian and effeminate. such images should not be taken as straightforward descriptions of actual garments however, since these accusations are topoi that mirror roman oppositional categories of thinking (male, traditional, roman clothing vs. effeminate, ânewâ, foreign/barbarian dress). they are used as rhetorical weapons in order to discredit actual or potential political leaders, including emperors. they can, however, serve as indicators that new materials like silk, or garments that served to represent status in other cultures such as those influenced by the hellenistic kingdoms, were âtried outâ by emperors (or their near relations). such emperors, beginning with âbadâ ones like caligula, nero and domitian, defied the unwritten laws of the early principate of being the âfirst among equalsâ and openly displayed their status. as has already been noted by others, even though innovations introduced by âbad emperorsâ might have been openly condemned, they were still often tacitly retained. this project has demonstrated that âbad emperorsâ were also trendsetters for novel ways of status representation through garments. this is corroborated by the sources that do not mirror the view of the senatorial elite, where another picture regarding luxurious garments emerges. these sources are, for example, texts of the court poets who praise or accept garments that the moralizing texts condemn. another corrective source for the moralizing views (that are repeated by christian authors) are legal rulings. they show that from the middle of the 4th century ce the emperors openly attempted to monopolize the use of certain materials and garments (silk, purple and gold, and also the use of some jewels, see publication on the emperor honoriusâ garments). the same is true for the women of the elite. although moralizing authors often condemned their appearance as too luxurious and immoral, a close reading of the texts reveals that both they and their relations had another perspective on their garments. rather than disgracing their families and particularly their male relations, they represented the family wealth (thorstein veblenâs model of vicarious consumption) and probably also showed off their physical beauty that reflected well on their husbands. the results from this section have been presented at talks in universities in frankfurt, hannover, athens, aarhus, copenhagen, buchara and tampere and are currently being prepared for publication in the form of two articles.   
the edict on maximum prices, issued during the reign of diocletian in 301 ce, lists maximum prices for services and goods, inter alia precious clothing and textile-related work (see also article on silk trade and production and the article by hildebrandt â flemestad â harlow â hildebrandt â nosch on textile tools in the edict). among the highly precious materials and elaborate weaving techniques are purple-dyed and damask silks. these items continue to be condemned in literary texts, but were obviously widespread enough to merit an entry in an inscription that claimed to cover the whole empire. the epigraphic record thus confirms that at least under diocletian (if not even earlier) a turning point in the use of precious garments had been reached that matched important political and institutional changes.  
sculptural evidence can add yet another facet, once the cutting-edge research on surface-treatment and color on statues is taken into consideration. this project has shown that color research can enhance the written sources in completely new ways, and surface details can give information about the intended characteristics of the garments depicted. even if statues seem to corroborate the predilection of the literary texts for traditional roman clothing and particular recurring types of representation, such as the togatus, long into late antiquity, the color of the garment can add a completely new meaning. this is the case for a new color reconstruction of a statue of caligula as togatus. depending on the reconstruction carried out by archaeologists and conservators, the toga might have been fully red/purple, thus indicating a triumphal garment. this means that without the knowledge about the colors, caligula was seemingly depicted in the traditional toga as a âfirst among equalsâ while in reality he used the purple toga that showed him as a triumphant general. interestingly, moralizing authors complained that he wore the triumphal toga even without being a victorious general. the color reconstruction of the garment as a triumphal toga could thus be read as his attempt at taking a traditional garment out of its temporal context in order to convey his elevated status (see article on the emperor honoriusâ garments). the project could thus demonstrate that colors on statues could be used to play with identities and status.  
another strong focus of research included the production and trade of the material that proved to be â next to purple â the most important for imperial representation: silk (see articles on silk trade and production and the edited volume on the exchange of silk along the silk roads).   
a further important result was to show how the epigraphical record can complement other kinds of written evidence. this was undertaken by research into an inscription regarding maximum prices of dress, textile material and tools that was issued under the reign of the emperor diocletian in 301 ce and that highlights the clothing habits of its time (see article on silk trade and production; and the article by flemestad â harlow â hildebrandt â nosch on textile tools in diocletianâs price edict).  
practical textile courses as well as collaborations with the colleagues from the ny carlsberg glyptotek copenhagen who work on color on statues (http://www.trackingcolour.com) have given the project a completely new dimension that adds to traditional views in both philological and archaeological research.   
the impact of the project lies in its relevance for archaeological, historical, philological, political and social sciences. among the most important results are the following: relying on one particular kind of material will bias any historical interpretation. senatorial ideology, court poetry and laws show many different levels of one and the same ârealityâ, as color on seemingly white statues does. only a combined methodology gives a rich and varied picture into ideal and actual strategies of representation that seem much more varied than previously assumed: the visualization of power through dress needs a transdisciplinary approach. this led to the result that contrary to common belief, already under the very first emperors constant attempts at status distinction through dress were the norm rather than the exception. the texts have to be read against this background. secondly, scientific research into colors on statues and dyestuffs as well as archaeological textiles in general open completely new aspects on status representation through elaborated clothing that was much more common than the literary discourses make us believe. the negotiation of status display through dress between emperors and subordinates, and particularly the political elite, was a constant process that caused considerable tension until ca. the 4th century ce. during the principate, it is argued, it mirrors struggles over political control within a peer-group. after that, it mirrors negotiations regarding the participation in monarchical power that was conveyed through outer signs like clothing. the attempts of the emperors at establishing monopolies for precious clothing items show that their status representation was not debated any more â the question was only whether they were allowed to do so exclusively.   
project webpages:   
http://ctr.hum.ku.dk/economy/emperors\_new\_clothes/  
http://ctr.hum.ku.dk/people/staff-list/?pure=en/persons/404974

# HVRCFM

Project Acronym: HVRCFM

programme & topic: FP7-JTI JTI-CS-2011-1-ECO-01-025

Most frequent returning words in objectives:

* ('fibres', 97)
* ('waste', 41)
* ('process', 40)
* ('materials', 37)
* ('fabric', 31)
* ('found', 31)
* ('fibre', 29)
* ('thermoset', 27)
* ('tape', 27)
* ('sliver', 27)
* ('production', 27)
* ('carbon', 23)
* ('yarn', 23)
* ('material', 21)
* ('aramid', 21)
* ('prepreg', 20)
* ('resin', 19)
* ('epoxy', 19)
* ('laminates', 18)
* ('matrix', 17)
* ('length', 16)
* ('slivers', 16)
* ('work', 15)
* ('properties', 15)

executive summary:  
1.1 executive summary  
  
this project was targeted at identifying sources of recycled and/or recovered carbon fibres and developing technologies to convert them into reinforcements by blending them with other suitable raw materials. these reinforcements can eventually be combined with thermoset and/or thermoplastic resins for manufacture of composite parts for a variety of applications. the objectives of the project were successfully achieved in the stipulated time-frame.  
  
the entire project was divided into separate work packages which encompassed all the objectives for the project. the different work packages are described below which summarize the outline of the project â   
  
wp1 - determine source materials for recovery of waste materials  
  
wp2 - development of hybrid yarn and tape materials suitable for downstream processing in thermoset composite manufacture.  
  
wp3 - define suitable weave styles or material structure for the samples to be provided.  
provide perform materials as required for sampling purposes.  
provide a method of fabric conversion suitable for the end user and the yarn properties.  
  
wp4 - characterisation of materials produced at yarn and fabric stages.  
  
wp5 - deliver the desired material to support jti-cs-2011-1-eco-01-25 call.  
  
  
project context and objectives:  
1.1 summary description of project context and objectives  
  
the major objectives and context of the project has been described in the above section as part of the different work packages.  
  
a detailed summary of the project objectives is as follows â   
  
wp1 â   
  
determine source materials for recovery of waste materials  
  
â¢ characterisation and assessment of suitability of end of life recovered cf and process waste streams (til,  
sig)  
â¢ small scale process trials of identified waste streams to confirm suitability (til)  
â¢ potential modification of cf waste presentation to optimise processing performance (til/sig)  
â¢ quantification of available and suitable waste streams for commercial processing (til/sig)  
â¢ selection of optimum yarn manufacturing route for main waste streams identified (til)  
â¢ identification of all potential thermoset compatible fibres for blending with waste cf (til)  
â¢ identification of potential thermoplastic compatible fibres for blending with waste cf (til)  
  
  
wp2 â   
  
development of hybrid yarn and tape materials suitable for downstream processing in thermoset composite manufacture.  
  
  
supply of suitable raw materials for larger scale trials (sig)  
â¢ hybrid yarn manufacture from end of life discontinuous waste cf and thermoset compatible fibres (til)  
â¢ hybrid yarn manufacture from discontinuous process waste cf and thermoset compatible fibres (til)  
â¢ commingled yarn manufacture from continuous waste cf and thermoset compatible fibres (til)  
â¢ supply of narrow thermoset tape materials for ncf and woven fabric manufacture (til)  
â¢ supply and characterisation of wide thermoset ncf materials (til/sig)  
â¢ supply of hybrid thermoplastic yarn and tape materials from discontinuous cf (til)  
  
wp3 â   
  
define suitable weave styles or material structure for the samples to be provided.  
provide perform materials as required for sampling purposes.  
provide a method of fabric conversion suitable for the end user and the yarn properties.  
  
  
â¢ input will be required from all partners on the material structure requirement. from the outset each partner will  
need to determine the required architecture so that a suitable material can be defined and designed (sig).  
â¢ the machine parameters will need to be programmed to manufacture the samples and loom setup will take place to manufacture required samples (sig).  
â¢ in the case of ncf all samples will undergo evaluation to determine suitable process parameters (sig).  
  
  
wp4 â   
  
characterisation of materials produced at yarn and fabric stages.  
  
this wp will provide the information for subsequent processing and will determine the optimum route for the converted fibres and materials (sig).  
  
  
wp5 â   
  
deliver the desired material to support jti-cs-2011-1-eco-01-25 call.  
  
the wp will monitor timescales and deliverables to ensure demonstrator articles and reports are delivered in time to support the call.  
  
project results:  
  
1.3 description of the main s&t results and foreground  
  
materials  
  
 15% resin compatible fibres are required in the prepreg system, therefore some other suitable fibres such as aramid would be added, which will contribute to increase the mechanical performance of the composites.   
  
therefore, the following materials were sourced:  
  
(i). epoxy compatible fibres  
(ii). recycled carbon fibres  
(iii). recycle grade aramid fibres  
  
  
pei resin fibres  
  
 the following two types of pei fibres were sourced:  
 (i). pei 6.7 dtex  
 (ii). pei 2.2 dtex  
  
 as the finer fibres provide better sliver quality, the 2.2dtex pei fibre was selected to  
blend with cf and aramid.   
  
virgin waste cf   
  
t700 types cf in multi-axial waste (max 5) were supplied by sigmatex.   
  
aramid fibres  
  
the following four types of recycled grade aramid fibres (1.7dtex linear density) were sourced:  
(i). type 1  
(ii). type 1t  
(iii). type 2 and   
(iv). type 55   
  
depending on the suitable fibre length, only type 55 was selected.   
  
fibre length distribution of aramid fibres  
  
the mean length and length distribution of sourced aramid fibres were investigated.   
it was found that type 1, 1t and 2 samples contain 40% longer fibres, ranging from 80-  
150 mm long, which are considered not to be suitable in our carding process   
  
type 55 was selected due to shorter fibre length, for better mixing and blending with similar length of cf and pei fibres.   
  
  
initial trials for cf/pei/aramid sliver production  
  
as it was decided that 50% cf will be blended with 15% pei and 35% aramid fibres, therefore, an initial sliver production was trialled by using this combination.   
  
pre-opening the aramid fibres  
the aramid fibres were pre-opened by pre-carding of the fibres before mixing with cf and pei.  
  
pre-opening the pei  
the pei fibres were also pre-carded to separate the fibres for better blending with cf.  
  
cf/pei/aramid sliver production trials  
continuous sliver with 2.5 g/m linear density was produced successfully. it was found that sliver can be made from the above blends that can be used in further processes such as tape and ncf production.  
  
cf length distribution in sliver  
cf length distribution was measured in the blended slivers.   
  
  
development of carbon fibre and epoxy resin soluble fibre based yarns and fabric for thermoset composite manufacture trials. the following objectives were set out:  
  
(i) selection of suitable waste carbon fibres  
(ii) selection of epoxy resin soluble/compatible matrix fibres  
(iii) commingled yarn and fabric production  
  
  
selection of waste carbon fibres  
  
chopped/staple carbon fibres (60 mm long) being generated as waste during the multi-axial fabric production process (max-5) at sigmatex, were selected in this work package.   
  
  
selection of epoxy resin soluble fibres  
  
to produce yarn from waste cfs, suitable carrier fibres are required to blend with staple cfs during carding process. the crimped carrier fibres will carry the un-crimped cfs during the carding process. moreover, during the composite fabrication, the epoxy soluble fibres will be dissolved in the matrix system and will work as toughening compounds in the composites.   
  
therefore, suitable epoxy soluble resin fibres were sourced and selected as carriers in this work package to produce spun yarns using waste carbon fibres. as thermoset (epoxy resin) compatible matrix fibres are limited in availability, therefore, only two fibres have been identified to be used with staple cf fibres as follows:   
(i). poly ether sulphone (pes)  
(ii). ultem polyetherimide ( pei)   
  
(i). pes fibre: pes fibres supplied by cytec were characterised. this fibre can be dissolved in epoxy system easily, but the physical properties of the fibres were found very poor to process. moreover, it was found that the pes fibres were non-crimped, very weak (breaking load only 0.093n) and fell into parts during carding process. therefore, it was not considered as suitable carrier fibres for staple cfs.   
  
  
(ii). pei fibres: ultem pei resin fibres (tg 217o c) were sourced from fibre innovation technology, usa. it was found that pei fibres were strong, crimped (10-12 crimp/inch) and in staple form (60 mm length) could act as an efficient carriers of staple cfs in carding process. this fibre was also found to dissolve in epoxy system, and therefore, was selected as epoxy compatible fibres.   
  
the following two types of ultem pei fibres were sourced:  
  
 (i). pei 6.7 dtex  
 (ii). pei 2.2 dtex  
  
  
commingled yarn manufacturing   
  
cf/pei (60/40) blends  
  
the max 5 waste carbon fibres and ultem pei fibres (2.2dtex) were finally selected to produce yarn. the blends of waste carbon with pei carrier fibres (60/40 weight ratios) were converted into continuous sliver using a modified carding process. then the slivers were used to produce spun yarn of 1100 tex by filament wrap spinning process. during the wrap spinning process, pei filaments were also used as wrapper to produce continuous yarn. the yarns were then delivered to sigmatex for woven fabric production.   
  
blending of higher cf% (over 60%) with pei fibre made the carding process difficult. moreover, it was found that the yarn contains a significant amount of loose fibres that causes problems in weaving process. therefore, yarn route was rejected by the partners for further development work.   
  
as it is difficult to increase the cf% in the sliver (reported in d2.1) to >70% due to the limitation of the processing performance of the blends in the carding process, the addition of waste aramid was identified as a possible solution to the problem to act as both a carrier fibre and additional reinforcing fibre. the main objective of this work package was therefore to produce hybrid sliver from cf/ aramid blends. it was also identified that tape from cf/aramid could be another interesting option for thermoset application. the following targets were identified for the work package:   
  
(i) production of cf/aramid and cf/aramid/pei hybrid sliver and  
(ii) tape production from cf/aramid blends   
  
both sliver and tape can be used in multi-axial fabric production process. for tape, a small % of thermoplastic fibres are required as a binder for the tape production process.   
  
   
development of slivers   
  
selection of materials   
  
the following materials were selected in this work package:  
  
(i) waste cfs (max 5)  
(ii) waste aramid  
(iii) maleic anhydride grafted polypropylene (mapp) thermoplastic fibres  
(iv) pei  
  
  
  
  
description the materials  
  
(i). waste carbon fibres: waste carbon fibres (60 mm long) generated during the multi-axial fabric production process (max-5) at sigmatex were selected.   
  
(ii). waste aramid: aramid fibres were added as second reinforcement fibre in the blend with cfs.  
  
(iii). maleic anhydride grafted polypropylene fibres: in the tape making process, a small amount of thermoplastic fibre is required as a binder to hold the cfs and aramid fibres in position and consolidate the tape. maleic anhydride grafted polypropylene (mapp) was selected as the binding materials due to the low melt temperature and high melt flow characteristics of this particular material .   
  
commingled sliver manufacturing   
  
the blending and mixing process of the cfs with carrier fibres reported in d2.2 report was also used in this work package. the following blend ratios were selected through discussion with the project partners:   
  
(i) cf/pei/aramid (cf 50%, pei 15%, aramid 35%)  
  
(ii) cf/aramid (70% cf 30% aramid)   
(iii) cf/aramid/mapp (50% 30% 20%)  
  
three different types of materials were produced and delivered to sigmatex and cytec for thermoset composite manufacture trials. waste aramid fibres work as a suitable carrier for staple cfs in the carding process by virtue of the high levels of cohesion exhibited. the slivers and tapes produced were found to offer acceptable levels of strength for multi-axial fabric production process. depending on the results achieved, further work is possible to reduce the level of mapp content while still retaining an acceptable level of binding.  
  
material conversion routes  
  
max-5 waste cfs and carrier fibres were converted into suitable textile preforms as part of wp2. various routes, were investigated to produce suitable composite prepregs from the selected materials.   
  
conversion of wcfs into continuous slivers  
  
  
blending of wcfs with polymer matrix fibres  
  
prior to composite prepreg production processes, it was necessary to produce continuous slivers from the waste carbon fibres. it is a challenge to produce sliver from chopped waste carbon fibres due to the non-crimped and brittle nature of the cfs. therefore, carrier fibres are required as a processing aid and the selected carrier fibres were blended with waste cfs in different weight ratios (depending on the thermoplastic or thermoset prepreg production) using a modified fibre opening and blending unit prior to continuous sliver production.   
  
sliver production  
  
the wcfs/polymer fibre blends were passed through a modified carding process, where the wcfs were further separated by a carding action. during the process of intermingling the cf (55 mm) with matrix fibres (60mm) on the modified card, it was found that the crimped polymer fibres acted as efficient carriers for the non-crimped cfs with minimum fibre breakage and resulted in good intermingling (âblendingâ). after carding, the blended cf/matrix fibre sliver was produced.   
  
a continuous sliver with 6-7 g/m linear density was produced successfully from the different blends required for both thermoplastic and thermoset composite prepreg production processes.  
  
conversion of slivers into tape   
  
it was found that the continuous slivers could not be used directly into new composite fabrication as they were very weak (breaking load 1-1.5n) and broke easily during handling in downstream processes. it was however found that partly stabilised/full stabilised (semi-consolidated /fully consolidated) sliver can be directly used in different prepreg manufacturing processes. as a result, a thermal consolidation process was constructed to stabilise the slivers into a tape. the details of the process was reported in d2.2 deliverable report.   
  
tape production process  
  
a thermal bonding technology was developed and constructed to produce semi-consolidated continuous tape from the carded sliver assembly. the whole unit contains three separate regions; fibre feeding, spreading and a heating zone. on leaving the drafting stage, the thin web of fibre is heated above the melting point of the pa66 polymer fibres and tension applied to produce further alignment of the carbon fibres. a pressure of 2 bar was then applied by a pair of pressurised rollers, âmeltingâ the matrix fibres to the carbon fibres to produce a 0.6 mm thickness semi-consolidated tape.   
  
  
  
during the tape making process, the contact dwell time (cdt) in second for pressure rollers and heating dwell time (hdt) were calculated.  
  
different types of tapes with different areal densities were produced for both thermoplastic and thermoset composite applications using different cf%.   
  
thermoplastic tapes  
  
the semi-consolidated thermoplastic tapes manufactured as thermoplastic composite prepreg contain 50-55% cf and 50-45% thermoplastic matrix fibres. during composite moulding, the thermoplastic fibres melt and act as matrix. these type of prepregs are found as attractive option for thermoplastic route as the tape/sheets are very flexible and light in weight. those tapes can be used directly as unidirectional prepregs and also can be slit into narrow widths for tape woven fabric production.   
  
  
thermoset tapes  
  
slivers produced from wcfs and aramid blends (70% 30%) and mixing with epoxy compatible carrier fibres (50% wcfs, 35% ar and 15% pei) or 60% cf 40% pei were converted to stabilised tapes (see figure 8). the subsequent tapes were used in ncf production line to make biaxial (+45o/-45o) fabrics.   
  
  
conversion of the tapes/slivers into non-crimped fabric (ncf)  
  
ncf production process  
  
the wider tapes produced using the tape-making unit were used directly for ncf production. another alternative route was also established to use the sliver directly into ncf production, where the slivers were partly stabilized using a binder and produce a wider sheet.   
  
   
biaxial non-crimped fabrics (ncfs) were produced by the continuous placement of the stabilized sliver sheets in a +45o/-45o lay-up protocol and stitch-bonded with a polymer filament yarn of 55dtex. the nominal weight of the ncf prepreg produced was 200â±10g/m2. figure 10 also shows the top and bottom surfaces of the ncf with plain and zigzag stitch patterns, respectively. the stitch density was 640/m2.   
  
conversion of waste cfs into continuous slivers by mixing with different carrier fibres has been developed. different routes for prepreg manufacturing using the carded slivers have also been successfully developed for both thermoplastic and thermoset composite applications.   
  
from initial work carried out by tilsatec, the route for material supply for 2d fabrics is tape. 60/40 cf/pet were provided by tilsatec and used as weft on a standard dornier loom. the use of tape for warp is not feasible at this time due to the amount of tape needed and the requirement for an alternative warp delivery system.  
woven 10mm tapes laminated (4layers only). consolidation was successful although warp and weft required for further research. sigmatex are currently trialling a new development machine which will be more suited to the manufacture of tape fabrics and will assess the recycled material when available.  
  
  
with plain, twill and satin weaves making up the majority of fabrics in the composites industry, tape woven demonstrators were manufactured to show the appearance of the fabrics using the recycle cf/pet tape. initial findings showed that the fibre was quite stiff and difficult to pick up by the standard rapier mechanism. given the width and the stiffness of the materials it was concluded that warp delivery would need to be updated and an alternative method of weft insertion would need to be realised to make the fabric a success. sigmatex has now purchased a new machine that is suitable for characterising and weaving the tape materials and will continue to develop these materials.  
  
manufacture ncf material  
  
the sliver produced by tilsatec did not have enough strength to be used directly on the ncf machine and needed pre-processing to allow transfer across the bed. the method of consolidation used a belt press to form a sheet of material which can then be placed on the bed of the machine at different angles. in this instance a 60:40 consolidated material was manufactured on the ncf to provide +/-45 degree material. this initial sample was then further processed to understand the processing parameters required for sample production. the university of manchester provided the facility of a hot press capable of achieving the pressure and temperature expected to process the fabric.   
  
the material was layered in 6 separate layers of 150 gsm per layer slivers to make a total fabric weight of 900gsm. the materials were pressed at a temperature of 260â°c for 1 hour at a pressure of 10 bar. the resultant materials, although consolidated had significant dry spots and the through thickness bonding was poor.  
  
subsequently further trials were carried using 8 layers at +/-45 degrees out at higher pressure of 50 bar and at a higher temperature of 290â°c. the cycle time was reduced from 1 hour to 15 minutes and the resultant material had good consolidation. testing showed that although there appeared to be good consolidation, under testing the material had high porosity.   
  
prepeg analysis  
analysis of cf/matrix fibre blends  
it was observed that the pa66 matrix fibres had acted as a carrier of the non-crimped carbon fibres during carding process thereby giving cohesion to the commingled mass, which enabled the production of the waste carbon fibre/pa66 (wcf/pa66) continuous sliver with linear density 6-7g/m. sem images of sliver specimens showed that the cf fibres were uniformly commingled/blended with the matrix fibres and reasonably well aligned with the sliver axial length.  
  
analysis of non-crimped fabric (ncf) prepregs  
biaxial non-crimped fabrics (ncf) were produced from the slivers and tapes for both thermoplastic and thermoset composite applications. it was mentioned in d2.4 report that the ncf prepregs were produced by the continuous placement of the stabilized sliver sheets in a +45o/-45o lay-up protocol and stitch-bonded with a pa66 filament yarn of 55dtex. the nominal weight of the ncf prepreg produced was 400â±10g/m2.   
  
two types of ncf prepregs were produced as follows:  
  
i. ncf thermoplastic composite prepreg. this prepreg contains 50% cf and 50% pa66 thermoplastic polymer fibres. the pa66 polymer fibres will melt and form the polymer matrix.  
ii. ncf thermoset composite prepreg containing up to 70% cf or mixture of cfs with aramid fibres. additional resin is required to make composite parts  
  
it can be mentioned here that the ncf was found to be highly formable and could be used in many complex composite shapes.   
  
conversion of thermoplastic fabric prepregs into composites  
   
a 3 mm thick laminate was fabricated using an 8-ply stack of the biaxial (+45o/-45o) noncrimped fabric prepreg, where the fabric plies were cross-laid in a manner which re-orientated the +45/-45o fibre inclination and produced a [0/90o] layup. hot compaction, 280oc temperature and 50bar pressure for 15min was used to consolidate the ncf assembly. the high pressure (50bar) was used to compress the bulky stack of the dry ncf plies to obtain full consolidation.   
  
fabrication of thermoset composite using noncrimped fabrics  
  
three types of thermoset laminates were fabricated using two types of epoxy resins: ltm217 and mtm57. semi-cured epoxy resin films were used in both cases. the resin films were applied to the fabric to produce laminates containing 55% resin (by vol.) in final laminates. the bi-axial (-45 /+45) ncf fabrics were cut for a 0/90 lay up and 6 plies of fabric were used to obtain 3 mm thick laminates. the cf-af-mapp tape prepreg (discussed in d2.4 report) was laid up 0/90 to obtain a balanced structure.   
  
  
total reinforcement wt. fraction and volume fractions were calculated from the density of the fibres and resin in individual laminate. cf weight fraction and cf volume fraction were also calculated in the composite laminates using the following formula:   
vc = 1/ [1+ pf/ pm (1/wc â1)]  
  
where, vc is total carbon fibre volume fraction in laminate. wc is cf weight fraction. pf and pm are the densities of the cf and resin, respectively.  
  
  
mechanical testing of composites  
  
tensile testing   
the tensile properties of the specimen were tested according to astm d3039-08 standard. a tabbed rectangular specimen (see fig. 30) was mounted in the grips of the test machine (gauge length 138 mm) and load was applied to the specimen at a constant rate of speed until the specimen failed. the ultimate tensile strength of the specimen was calculated from the failure load.  
  
flexural testing   
flexural properties of the laminates were tested according to the bs en iso 14125 standard. a rectangular specimen was cut into 80 mm length and a span to thickness ratio of 16:1 mm was used. loading was applied at a constant crosshead rate of 5mm/min at the centre of the span length. the load applied to the specimen and the deflection were measured during the test. the flexural strength and flexural modulus were calculated.  
  
compressive strength  
compressive strength of the laminates was calculated according to the astm d695-89 (boeing modification) standard. a tabbed rectangular specimen with a 4.8mm gauge length was mounted in cruciform anti-buckling jig. load was applied through the end of the specimen at a constant rate (1.3mm/min) of crosshead speed until the specimen failed. the ultimate load at which catastrophic failure occurred was used to calculate the compressive strength.  
  
inter-laminar shear properties  
inter-laminar shear strength (ilss) was according to the astm d2344-84 standard by using short beam method. the beam size was 20 mm.  
  
  
the rectangular specimen was centrally loaded at 1.3mm/min in a three-point bend fixture until the failure occurred. the test support span to specimen thickness ratio was 5:1. the ilss was calculated.   
  
results and discussions  
  
cf/pa66 thermoplastic composites  
  
the fabrication procedure of cf/pa66 thermoplastic laminates and methodology of different tests were described in section 3 and 5. the ncf composite fabricated contains 4 layers of prepreg in the 0o direction and further 4 plies in 90o direction on [0/90]o lay up. the mechanical tests of the ncf composites were conducted in 0o direction.   
  
the average tensile and flexural strengths were found to be 255.9mpa and 192.5mpa, respectively. the average tensile and flexural moduli were 22.14gpa and 18.01gpa respectively. as the ncf composite contains 4 layers of prepreg in the 0o direction and further 4 plies in 90o direction, 50% (i.e. 4 plies) of the fibres in 0o contributed to both tensile and flexural properties.   
  
  
the average compressive strength and modulus were found to be 122.68mpa and 23.6 gpa, respectively. the ilss was found to be 15.11 mpa of the ncf laminates.   
  
  
it was found that the composite panels made from the ncf, showed no traces of the stitching threads used in the making of the ncf prepreg. both the constituent pa66 staple fibres in the slivers and the pa66 filament stitching threads on the fabric surface, that held together the fabric structure, had melted and had diffused during consolidation of the composite panels. however, the sem image (50 x magnifications) obtained from the cross-section of the laminate showed the laminate contains a significant number of voids.   
  
  
due to the large void%, the density of composite made from the ncf was measured to be 1.19g/cm3: significantly lower than the calculated value (1.39g/cm3); the low value indicates a relatively high void content calculated to be ~14%. the high void content is most likely due to an insufficient level of matrix fibres to impregnate the cf presents. the density and hence the porosity and mechanical properties of ncf composite could be potentially enhanced by:   
- optimisation of matrix fibres %  
- use of finer matrix fibres  
- improved uniformity in fibre mixing  
  
  
comparing the results of bi-axial ncf composite sample (fabricated in this project) with a commercially available (tenax, germany, cf/pa12 yarn) composite made of stretch broken cf/pa12 commingle ud yarn laminates in not applicable as the available material was made from longer cf (70-90 mm long) commingled yarns. it is reported that the flexural modulus of tenax cf/pa12 ud composite (50% cf by vol.) were 60 gpa, which effectively equivalent to 30 gpa in bi-axial format. flexural modulus obtained for the bi-axial ncf composite was 18.5 gpa for 36% cf by volume which is equivalent to 26gpa for 50% cf by volume. so, it is found that the modulus of ncf composite is only 13% lower than equivalent virgin tenax cf/pa12 composite with same cf volume fraction in similar format. this is due to the short/discontinuous wcf used in ncf prepreg in this project and the high porosity (10%) found in the laminates also has reduced the mechanical properties of ncf composite.   
  
  
thermoset composites  
  
the fabrication procedure of epoxy thermoset laminates and methodology of different tests were described in previous sections. the ncf epoxy composite fabricated contains 6 layers of prepreg in the 0o direction and further 6 plies in 90o direction on [0/90o] layup. the mechanical tests of the epoxy composites were conducted in 0o direction. the results obtained from different test are discussed here.   
  
by analysing the test results it was found that all three ncf/epoxy composites have similar tensile strength ranges from 225 mpaâ240 mpa. the flexural strengths were found to be from 362-386 mpa, the compression strengths were found to be from 228-255 mpa and ilss were also found to be from 32-43mpa. the strengths were found very similar in all samples.   
  
similar trends were also seen on their stiffness values, where the tensile moduli were from 15.5 to 19.5 gpa, flexural moduli were from 15.5 to 18.5 gpa and the compression modulus were from 14 to 17.3 gpa, respectively.it was also found that using of small % of pei with cf has little effect on the compositeâs properties  
  
according to a cytec materials property archive, continuous carbon fiber 2x2 twill fabric/epoxy composites (55% cf volume fraction) can reach tensile and flexural modulus of 64.6 gpa and 61.36 gpa, respectively, which are much higher than the 19.5gpa tensile stiffness and 18.5gpa flexural stiffness values of the ncf epoxy composites. the lower stiffness values of ncf/ epoxy laminates were due to shorter cfâs length and lower cf volume fraction in the laminates. the average cf length was found to be 40mm and the cf volume fractions were found to be 28% in cf/ar/epoxy laminates and 20% in other ncf/epoxy laminates. moreover, all the epoxy laminates were fabricates using a film stacking process, therefore, resin infusion inside the bulky fabric layers may not have been sufficient to fully wet the cfs resulting in poor mechanical performance. resin infusion process has been recommended instead of film stacking process to achieve better mechanical properties from the ncf fabrics in future work.   
  
  
conclusion  
  
based on the results and discussion above, key points may be concluded as follows:   
- a novel process for producing cost effective rcf/pa66 thermoplastic non-crimped bi-axial fabric has been developed to provide a dry-prepreg. the ncf thermoplastic prepreg (400g/m2) may be considered as a promising material for lightweight composite applications. it was found that the rcfs are relatively aligned and well distributed/blended with matrix fibres. therefore, good mechanical properties of ncf thermoplastic composites were achieved. however, the properties may be improved by using finer resin fibres, better mixing of the fibres and improved composite fabrication technique.  
- a novel cost effective rcf thermoset non-crimped bi-axial fabric has been developed from waste carbon fibres but the ncf thermoset fabric prepregs contain very lower % of cfs. the fabric prepregs were found to be very light in weight (300g/m2) and suitable for any complex composite shapes. the mechanical properties of the rcf/epoxy composites were also found to be good on the basis of the cf% in the laminates but can be further improved by increasing cf% in the prepregs. it was also found that the ncf is more suitable for resin infusion process instead of resin film stacking and likely to provide improved mechanical properties.   
  
finally, it can be concluded that the both ncfs for both thermoplastic and thermoset composite applications can be attractive materials for composite end users in many applications as a potential replacement for virgin cf and heavy weight glass fibre composites. the ncf production process from waste /recycled cfs can be one of the suitable processes to re-use the waste fibres into higher value composite manufactures than those currently commonly employed for waste materials.   
  
potential impact:  
with growth of the use of carbon fibres increasing significantly within aerospace and automotive sectors, waste levels will also increase. by having a method and supply chain to create new materials from virgin waste the impact for future manufacturing is much improved. as the cost of fibre reduces even further, more widespread use of carbon fibre is anticipated in wider markets. through the course of this project the ability to manufacture a thermoplastic carbon with the matrix already integrated in the material has been demonstrated. the opportunity to create a structure by just pressing the material reduces processing time and also reduces the need to use other thermoplastic matrix materials.   
with cycle times for processing of materials into automotive being a primary driving force, it is expected that the materials developed through this process will find uses where stiffness is required and thermoforming is an option. the high dry fabric waste levels that are currently being demonstrated in the automotive sector at approximately 40%, could be incorporated into the materials deve ...

# ITEM-E-CONTEXT

Project Acronym: ITEM-E-CONTEXT

programme & topic: FP7-PEOPLE FP7-PEOPLE-2013-IIF

Most frequent returning words in objectives:

* ('textile', 22)
* ('fellow', 22)
* ('project', 12)
* ('tools', 11)
* ('cyprus', 10)
* ('weights', 7)
* ('bronze', 6)
* ('research', 6)
* ('loom', 6)
* ('enkomi', 6)
* ('iron', 5)
* ('material', 5)
* ('museum', 5)
* ('results', 5)
* ('training', 4)
* ('nosch', 4)
* ('copenhagen', 4)
* ('industry', 4)
* ('data', 4)
* ('paper', 4)
* ('mediterranean', 3)
* ('period', 3)
* ('knowledge', 3)
* ('study', 3)

identities and transformation in the eastern mediterranean: evolution and continuity of textile tools in the late bronze age (lba) and early iron age (eia); 13th - 10th c. b.c.e.  
  
the goals of this research project, which started in june 2014, were to establish a better understanding of the problematic transitional period at the end of the late bronze age, and to advance our knowledge of this poorly understood period by:  
[1] studying together key aspects of the development of textile technology in the late bronze age and the early iron age, two periods that belong to different scholarly fields and are not addressed by the same scholars.  
[2] demonstrating the value of using textile tools and technological changes associated with textile production as marker for population changes and renewal.  
  
to do so, the fellow has received training in a new methodology of the study and recording of loom weight by her supervisor m.l. nosch. the fellow has shared knowledge and discussed textile tools with the other fellows and colleagues at the centre for textile research in copenhagen. she has also participated to the âfestival international du linâ in france and has learned about linen industry but also about traditional flax cultivation, harvest and fibre processing, which are highly relevant for her research.   
concerning the transfer of knowledge, the fellow has been sharing her expertise on textile industry in cyprus and the near east with colleagues from ctr. this will for instance lead to a joint article with m.l. nosch and l. rahmstorf on textile tools (list of publications number 10). as stated in her mc project, the fellow has also used her expertise on syrian textile tools to study material from hama kept at the national museum in copenhagen, the publication of the material is in progress.   
the fellow collected data on textile tools in copenhagen (national museum), and during field trips to stockholm (medelhavsmuseet), london (british museum) and paris (le louvre) in 2014 and 2015. she also travelled to cyprus in 2015 and collected and documented data in museums. in addition to collecting data in museums, the fellow started to work on unpublished publication notebooks kept in paris on the excavations conducted at enkomi (cyprus) to better understand and interpret the textile tools of the site and their archaeological context. the unexpected amount of textile tools from enkomi was a significant gain to the project and will in the future lead to either a monograph or a comprehensive paper.  
during the project, the fellow fulfilled her first objective, which was to provided currently lacking weight and precise measurement information for the ivory and bone shafts from the late bronze and early iron ages, as well as measurements of clay loom weights from cyprus. the fellow also drew and photographed most of the objects that she recorded. the fellow has also started to establish a catalogue of possible distaffs and spindles in metal according to publications.  
the second objective of the project was to address the possibility of identifying new comers in early iron age northern syria and cyprus by examining the archaeological evidence for the introduction of new spinning technologies and shifts in low and high whorl use. for this, the fellow started to study textile tools from syria and cyprus in museums. although, the fellow has not yet been able to analyse all of the data that she collected, she has gained a good understanding of the cypriot lba textile industry, its character and extension. the first results and conclusions are published in the paper sauvage, c. & smith, j. âlocal and regional patterns of textile production in late bronze age cyprusâ, to be published in ancient cyprus today: museum collections and new research approaches to the archaeology of cyprus (submitted fall 2015).  
  
the fellow is currently working on the publication of textile tools from hama and from enkomi. the fellow intends to publish a monograph or comprehensive paper on the textile industry at enkomi, and she is also working on other sites in cyprus to provide comparison for the rich enkomi material, and will publish the results in a large peer-reviewed article. for enkomi, her main results are the identification of textile workshops in the city and in an official building (fig. 1), where the manufactured fabrics were fine, light-weight and narrow. it is for the moment unclear if the domestic productions differ dramatically from those of the artisanal area. however, it seems that sets of terracotta loom weights were produced by a specialized workshop, which tends to make pyramidal loom weights of an identical shape and weights, often found by groups of 7 to 14 pieces. four types of spindles were identified by the fellow, and by studying material from tombs, the fellow was able to reconstruct spinning sets, and to demonstrate that the same spindle could have been used with whorls of different weights and diameters to produce threads of varying thicknesses. some of these whorls weight as little as 1 g, and correspond to objects that have so far been discarded in textile studies.  
  
during the extent of her project, the fellow has increased her exposure on the international scene by attending several international conferences: 9th icaane in may 2014 (in basel), asor conference in nov. 2014 in san diego, and âcyprus in the museumsâ in the stockholm museum (april 2015). in the fall of 2014 (september-november), the fellow has been travelling in the usa, to join supervisor m.l. nosch on research stay in the usa, to be trained in textile technology, especially in the new ctr methodology of the functioning of loom weights. this training was necessary to enable the analyses of her collected material. a special gain of this joint training program was that we discovered an assemblage of unpublished loom weights from the getty villa, and we are now in the course of publishing them together in an international journal. (see list of publications). the first results of this research project were presented in december 2014 at an international workshop in copenhagen in a joint paper by the fellow and the supervisor. the fellow also organized an international conference with textile scholars in los angeles. this gave her the opportunity to extend her international network and present the preliminary results of her project to textile experts. moreover, the fellow started collaboration with m.-l. nosch and l. rahmstorf, on the transition from the late bronze age to the early iron age with a special focus on textiles tools in the eastern mediterranean (crete, greece, cyprus and the levant).  
the fellow was invited to join the gdri (groupement de recherche international) atom (ancient textiles in the orient and mediterranean) for the period 2015-2018 as a direct result of the mc project. the grdi is a formalised network between ctr, cnrs and leicester university.  
the fellow took leave from the project to obtain more training in teaching courses in archaeology (in loyola marymount university), and was subsequently offered a tenured position. thus she only completed 11.5 months of the planned project.  
  
â¢ provides the address of the project website (if applicable) as well as relevant contact details.  
http://ctr.hum.ku.dk/economy/identities\_and\_transformation/

# MULTIHEMP

Project Acronym: MULTIHEMP

programme & topic: FP7-KBBE KBBE.2012.3.1-02

Most frequent returning words in objectives:

* ('hemp', 89)
* ('fibre', 60)
* ('quality', 50)
* ('traits', 25)
* ('processing', 21)
* ('crop', 21)
* ('production', 20)
* ('varieties', 19)
* ('genes', 19)
* ('breeding', 18)
* ('project', 18)
* ('multihemp', 17)
* ('applications', 17)
* ('system', 16)
* ('biorefinery', 15)
* ('trials', 15)
* ('materials', 14)
* ('fibres', 14)
* ('biomass', 13)
* ('targets', 13)
* ('effect', 13)
* ('developed', 12)
* ('field', 12)
* ('products', 11)

executive summary:  
in multihemp, a multidisciplinary team of leading researchers and a vibrant group of industrial participants, working from the level of molecular genetics through to end product demonstration, developed an integrated hemp-based biorefinery in which improved feedstock is subject to efficient and modular processing steps to provide fibre, oil, bio-composited, construction materials, fine chemicals and cosmetics using all components of the harvested biomass, and generating new opportunities within the developing knowledge based bioeconomy. advancements of technology readiness levels (trl) were obtained for several products. a formaldehyde-free hemp based panel system has reached trl 9 and during the course of multihemp a new industrial plant was inaugurated. a hemp-based blow-in insulation system reached trl 6 and is now processed for eu licencing. hemp-oil based cosmetics reached trl5. test on high-tech (using long fibre) and mid-tech (using hackling losses) biobased composites applications showed that hemp fibres have a real potential in replacing less environmental friendly materials, like glass fibres.   
to optimise the whole production chain and obtain materials and products of desirable quality, extensive research and demonstration activities were performed. adjustments and adaptations were performed at industrial scale and on innovative prototype systems. harvesting machines were tested and an innovative technology was designed and developed to increase seed quality and collect threshing residues for subsequent cannabinoids extraction. an innovative high-throughput quality evaluation system was developed and used to characterise thousands of stem and fibre samples.   
results from a large network of agronomic and physiological experiments supported a significant advance in hemp agronomy and the parametrisation and validation of the crop model gecros that is now a valuable tool for both growers and breeders in the ongoing development of a sustainable hemp production. two complimentary approaches to hemp breeding using both forward and reverse genetics were applied. while new varieties could not be generated within the span of the project homozygous mutant material has been produced for three targets genes related to fibre quality and led to a chemotype at the fibre level. one line was introgressed into the elite fibre variety futura. genotyping and phenotyping 124 hemp accession of the mapping panel, association mapping was performed and identification of qtls associated with interesting traits related to phenology and quality was accomplished.   
dissemination activities have taken place throughout the project, with research partners mainly attending scientific conferences and producing peer reviewed papers and industrial partners presenting their products to trade fairs and exhibitions. the forum of the annual international conference of the european industrial hemp association (eiha) has been used very actively throughout the duration of the project for an exchange between the project and scientific and industrial community. a stakeholder workshop organised in 2016 highlighted the main bottlenecks hampering the expansion of hemp cultivation in europe. a fibre quality workshop addressed to phd students and young researchers was successfully organised at the universitã© de lille (fr) on january 18th, 2016.  
project context and objectives:  
hemp is a high yielding crop well adapted to most european conditions, with advantageous environmental and agronomical characteristics. traditionally cultivated for the fibre, seeds and psychoactive substances and potentially for a wide array of other applications hemp is rightfully considered an ideal crop to produce multiple biobased materials (amaducci and gusovius, 2010).  
once a major industrial crop, hemp faced a worldwide progressive decline in the last century as its use for textiles was displaced by cotton and synthetic fibres. however, in recent years there has been renewed interest in hemp for a range of industrial applications due to the superior quality of its fibre in a number of uses, and because it is more sustainable than cotton (van der werf and turunen, 2008) and to manmade fibres in specific industrial applications (pervaiz and sain, 2003). in addition to fibre, hemp also produces high quality seeds with developing markets for the oil and protein. despite renewed interest, and obvious potential as a biorefinery crop, hemp remains poorly developed as it has not been subjected to intensive breeding in the last 50 years.   
as for any other crop, the competitiveness of hemp also relies on a favourable political framework (ragauskas et al., 2006). it is increasingly recognised that the political-economic framework for bio-based materials and products in the eu should be based on agreed and scientifically proven criteria such as climate protection, resource efficiency, employment and innovation (carus et al., 2011). in the face of great global challenges in the area of climate change, food security and diminishing reserves of fossil fuels, the role of a low-input high yielding crop able to provide a range of high quality renewable materials and chemicals, such as hemp, could not be more timely. however, considerable effort in the area of crop improvement, farm and process innovation, and supply chain development are needed before the full potential of hemp as a biorefinery crop can be realised.  
in order to drive forward the innovations needed to bring to market sustainable and biodegradable biomaterials multihemp will develop an integrated biorefinery based on hemp. this will be advanced by developing the âgreen factoryâ concept harnessing the natural potential of this crop to deliver high quality raw materials, and developing integrated processing systems to obtain maximal value from the crop in a sustainable manner. the work will be industrially driven and include demonstration activities to underpin new opportunities in the knowledge based bioeconomy.  
multihemp concept  
this research project aims at developing hemp genotypes with enhanced traits suitable for diverse cultivation environments and to provide improved feedstock for a wide array of innovative end products generated within an integrated biorefinery. our aim is to develop a modular biorefinery in which market forces will dictate the flow of raw material into differing product options. the production of long bast fibre for technical textiles and high-quality composites will be coupled to that of short bast fibre for injection moulded bio-composites and insulation products, as well as shives for low carbon construction materials, oil for health and personal care applications, protein for food and feed, and high value chemicals such as phytosterols, waxes, and essential oils. innovative applications will be developed for the by-products from processing routes including: dust from fibre processing, retting liquor from fibre degumming, flour (or cake) from oil extraction, and threshing residues from seed harvesting. industrial and processing requirements in terms of fibre and oil quality will be addressed in an integrative work package and will identify principal targets for cultivation and for the breeding programme. industrial destinations, with their respective quality parameters and production traits, will therefore drive breeding targets and improvements in crop management.  
the targeted improvements in hemp raw material quality will be driven by industry end-user requirements and be informed by state-of-the-art knowledge of relevant areas of plant biology and metabolic pathways and achieved using modern molecular tools. a better scientific understanding of genetic control of biomass quality will allow the identification of molecular markers and novel tools for plant breeding. commercial varieties, wild accessions and lines at different stages in the breeding pipeline will be tested in field trials across multiple locations. agronomic trials and physiological studies will be undertaken to study the effect of cultivation practices and growing conditions on biomass yield and quality. knowledge generated during agronomic and physiological studies will be used to calibrate and validate a crop model that will aid hemp breeding and cultivation.  
we will undertake studies into the economic and environmental implications of the newly developed genotypes coupled with the innovations in cultivation, harvesting and processing systems and the integrated hemp biorefinery concept as a whole in order to maximise potential benefits to the environment and rural economy. overall, the project is designed to maximize economic return (developing high added value applications), to increase environmental sustainability and to foster rural development.  
developing an integrated hemp biorefinery  
the concept of biorefinery developed within this project combines actual and innovative processing systems that, starting from harvesting, transform hemp biomass into a spectrum of marketable intermediate and final products. two main routes of hemp processing are defined by the harvesting method, and will be indicated as longitudinal and disordered (amaducci and gusovius, 2010). the longitudinal processing line was studied and developed in the hemp-sys 6fp project (amaducci, 2003) where an innovative procedure was introduced so that stems (harvested with a novel harvesting system) were âgreenâ decorticated (no retting was carried out on the stem) and the resulting fibre bio-degummed with patented technology. considering that one of the main problems of this system is stem âdecorticabilityâ (i.e. measured as efficiency of separation of shives from the bast fibres, therefore % of shives still attached to the fibre after separation) new varieties with looser bonds from xylem to bast fibre are desirable to improve system efficiency. the processing plant used to decorticate (scutch) the stems is the same used for flax (âlong fibre lineâ in figure a) and it can be combined to the processing systems used to separate short fibre fractions from shives in the disordered line (âshive separation and fibre refiningâ in figure a). long fibres are then bio-degummed, softened and hackled to be suitable for spinning or alternative destination.  
in contrast, disordered harvesting is the most common system employed for hemp with commercially available harvesting systems. cut stems are then left in the field to partially degrade for a period of time in a process called dew retting. bales of dew retted hemp produced in this system are fed into mechanical processing units to separate short fibres from shive. in the first step (decortication) shives and bast fibre are mechanically separated (bulk fibre) and in the subsequent steps shives are removed and bast fibres are divided in different grades. in multihemp an alternative disordered harvesting system that cuts the top of the plants with the seeds separately from the rest of the stem, will be developed so as to improve seed yield and quality, with the additional advantage of recuperating threshing residues that will be evaluated for the extraction of valuable chemicals.  
a key component of the programme involves the development of an integrated set of processes that will allow the realisation of a range of valuable by-products from hemp biomass.  
figure a  
rapid improvement of hemp using modern molecular breeding approaches  
the breeding strategy followed in multihemp comprises the characterization of natural variability genome-wide using modern high-throughput technologies, by deep sequencing of over 100 contrasting genotypes for different morphological and quality traits development of molecular markers for multiple traits in hemp, in-depth transcriptomic data for hemp, and a working platform for heteroduplex mapping.  
agronomic evaluation and crop modelling  
field trials have a central role in multihemp: supporting breeding activities; evaluating the effect of genotype, environment and management (g x e x m) on yield and main quality traits; improving and parameterising a crop growth model that will be implemented with empirical and mechanistic relations to simulate the effect of environment and management on quality traits, and further to optimise g x e x m.  
data from field trials will be used to improve and parameterise a crop growth model (gecros) to simulate and optimise the effect of g x e x m on fibre yield and quality. an elegant property of gecros is that while the model uses physiologically sophisticated algorithms to quantify crop growth, it requires minimum input parameters that can be easily measured with little destructive sampling needed, so it best suits for predicting the performance of a large number of genotypes under various environmental conditions. model validation will be carried out with data collected from multi-location trials carried out at the end of the project.  
quality integration along the hemp production chains   
unravelling the genetic basis of complex traits, like fibre quality, is limited by the lack of appropriate phenotyping platforms that enable high-throughput screening of many genotypes in multi-location field trials (montes et al., 2007) or numerous fibre samples obtained with contrasting agronomic techniques. the situation is further complicated considering that fibre quality cannot be univocally defined, in fact it depends on many parameters and the desired combination of these parameters varies with the specific end use destination. within multihemp integrated activities will be dedicated to the development of a high-throughput evaluation system to determine the suitability of hemp fibre for its main end use destinations (i.e. technical textiles, composites, insulation and building materials).  
a further challenge in the determination of quality along the production chain is the influence of harvesting and the combination of processing technologies (i.e. retting, fibre extraction, fibre separation). trials on commercial scale processing plants will be coupled to lab scale fibre extraction to study how fibre quality parameters evolve from the plant (potential quality) until end use application.  
economic and environmental evaluation  
the multihemp concept aims to maximise economic returns from hemp and strive for environmental efficiency by using the whole biomass in the best possible way in an integrated biorefinery. a techno-economic evaluation in multihemp will assess the costs and revenues at every process step of the hemp biorefinery, compare these with achievable prices of marketable products (target costing approach) and will derive from this calculation maximum prices for straw and/or seeds to be paid to farmers. there are good reasons to believe that hemp, and even more so in an integrated concept as proposed in this project, will fair well on many of economic and environmental criteria. the environmental implications of the hemp biorefinery will be evaluated by conducting life cycle assessments (lca) for the marketable products. their production in a conventional hemp production system as well as petro-chemical substitutes will form the reference systems.   
both the results of the techno-economic evaluation and the lca will be combined in an integrated sustainability assessment.  
multihemp objectives  
the overall objective of multihemp is to advance the scientific and technical research needed to consolidate and expand the market of hemp renewable materials.  
specific objectives are:  
â¢ a substantial gain in understanding the physiological and genetic basis of the relevant hemp traits will be achieved by applying modern molecular tools, evaluating the effect of environment and management in field trials, improving and parameterising a sophisticated crop model and developing a high-throughput evaluation system to determine the suitability of hemp fibre for its main end use destinations;  
â¢ develop hemp genotypes with enhanced traits suitable for diverse cultivation environments and a wide array of actual and innovative industrial applications;  
â¢ characterization of hemp varieties that are commercially available or in the phase of registration to identify their suitability for specific end-use destination;  
â¢ advances in agronomic practices;  
â¢ develop a modular biorefinery, in which market forces will dictate the flow of raw material into differing product options. the production of long bast fibre for textiles will be coupled to that of short bast fibre for bio-composites, shives for low carbon construction materials, oil for health and personal care applications, protein for food, and high value chemicals such as phytosterols, waxes, and essential oils. innovative applications will be developed for the waste and by-products from processing routes including: dust from fibre processing, retting liquor from fibre degumming, flour (or cake) from oil extraction, and threshing residues from seed harvesting  
â¢ an integrated sustainability assessment including life cycle assessment (lca) and a techno-economic evaluation will be carried out for the whole production system from breeding till end product marketing.  
â¢ dissemination and exploitation activities will be applied to raise the awareness of the versatility and sustainability of industrial hemp, to generate commercial value from research results and to provide a scientific basis for policy recommendations.  
  
project results:  
the main goal of multihemp, to sustain the use and production of sustainable and biodegradable materials from hemp biomass, has been pursued through an integrative approach involving the main phases of the production chain. actors and end users were consulted to define quality targets for hemp fibre and oil so to drive research activities within multihemp on stakeholder requirements. breeding of new varieties suitable for biorefinery applications followed both forward and reverse genetics. the latter approach was used in wp1 to target candidate genes for fibre characteristics (ease of retting and fibre separation, improved surface characteristics and higher digestibility for fuel production) and oil composition (high oleic hemp and high gla hemp). beneficial mutations related to fibre and oil quality were introgressed into elite varieties. a complementary approach was adopted in wp2 where association mapping was carried out to identify useful markers for breeding, and potential candidate genes for relevant fibre quality traits. for the scope an innovative, high-throughput fibre characterisation system was designed and developed in wp6.  
advances in agronomic practices to improve environmental sustainability and technical suitability of hemp cultivation for specific end use destinations were achieved through a series of field experiments carried out in wp3. evaluation of the effect of g x e x m on quality traits that influence end use destinations and increase hemp biomass exploitability was carried out in close integration with partners of wp6.  
in parallel to the above mentioned actions aiming at improving varieties and agronomic practices, multi-location trials were carried out to assess commercial varieties for specific quality traits. two commercial varieties of contrasting quality were used for demonstration trials involving industrial partners (wp4) to evaluate how extremes in their fibre quality affect the product quality along the production chain until end use application (wp5). in wp4 innovative and existing harvesting and processing systems were evaluated to demonstrate their effectiveness in determining yield and quality of hemp raw materials. system optimisation was performed in particular to increase exploitability of hemp biomass. for the same purpose an innovative harvesting system was designed to recover threshing residues during seed harvest. in wp5 threshing residues, dust from fibre processing and retting liquor, that are at the moment considered wastes or residual biomass, were analysed to disclose their potential for valuable applications. industrial partners provided (to wps 1-4) indications on desirable quality traits for specific end use destinations and assessed and demonstrated the effectiveness and technical feasibility of the developments implemented along the production chains introducing new varieties and optimising agronomic practices, harvesting and processing. partners of wp6 performed quality analysis on the materials produced along the production chain (wps 1 to 4) providing an essential contribution to the understanding on how quality is affected by single production factors (from genotype to fibre processing) and particularly integrating the concept of quality along the production chain. an integrated sustainability assessment including life cycle assessment (lca) and a techno-economic evaluation of the whole production chain was carried out in wp7 with the overall scope of identifying the most effective combination of production steps and the most efficient use of resources in the hemp biorefinery. in wp 8 a strategy for the dissemination and exploitation of research results was developed and implemented. this activity will also aid the development of efficient marketing strategies for hemp products and provide policy recommendations on how to better reap the potential societal benefits of hemp cultivation, processing and product development in europe in terms of higher value added, employment and environmental sustainability of hemp.  
wp1 heteroduplex mapping to improve hemp target traits  
objectives   
the aim of wp1 was to use a reverse genetic approach, heteroduplex mapping to improve hemp for biorefining applications. the project did not generate new varieties within the span of the project however it has demonstrated the potential and limitations of using hdm to create new varieties in hemp. key genes associated with lignin accumulation and phenotypic traits were identified in the project description for their potential effect on fibre quality and processability. they were cinnamyl alcohol dehydrogenase (cad), galacturonosyltransferase (gaut), reduced wall acetylation (rwa), pectin methyl esterase (pme). the aim was also to carry out field trials and demonstration activity with a mutant line already available at the university of york containing high oleic acid and high omega-3 in the seeds.   
an extensive analysis of gene expression in hemp was carried out using 18 cdna libraries from which gene sequence information was retrieved and in silico expression analysis completed using clustering and co-expression. this led to a database of 26 000 genes where homologs of our selected target genes were identified. figure 1 shows the results obtained for the cad family, a protein shown to affect lignin accumulation. using the arabidopsis lignin cad (atcad5), 16 hemp contigs were pooled and three showed higher number of occurrence in the stem libraries (figure 1a). cscad1 was identified as the hemp lignin cad as it clustered in the same clade as all the functionally characterised lignin cads (figure 1b). qpcr showed that cscad1gene expression is specific to fibres (figure 1c) and highly expressed in fibres in comparison to cscad2and cscad3 (figure 1d). a similar analysis was carried out for the other targets and the final list of selected targets is described in table 1. this work was completed with a second transcriptomic experiment focused on fibres at different stages of development. analysis of the expression of the selected targets in the fibre samples confirmed that all the selected targets were the main gene expressed in fibre for each gene family. together, a large transcriptomic database of hemp genes (300 000 contigs) has been generated with relevance for fibre applications but also most areas of hemp improvement. this database will be available for further projects.  
homozygous material has been produced for three targets csmho41b (cad1), csmh034b (csrwa2) and csmh045 (cscad2) but not for csmho69 (cspme1). a summary of the most promising mutant lines identified is shown in table 2. cscad1 is an important target for mutation breeding of hemp fibre characteristics because homologs in other fibre crops such as flax display a mutant phenotype (chantreau et al. bmc plant biol. 13:159, 2013). one missense mutation mh041b (e308k) has been taken forward and led to a decrease in lignin content in fibres (figure 2a). for csrwa2 a mutation introducing a premature stop codon (mh034b) has been taken forward and brought to homozygosity. the mutant lines exhibited a reduction in cell wall acetylation associated with a dwarf phenotype (figure2b). this mutation was introgressed into the elite line futura and heterozygous lines were identified. it has been possible to alter the cell wall properties of hemp fibres in two targets out of four showing that it was possible to reduce lignin and acetylation properties of hemp fibres and that the reverse genetic approach could be a powerful tool to generate new hemp lines. while the phenotype of the csrwa2 mutant would not be desirable for fibre applications, they provide an insight to better understand bast fibre cell wall which may have relevant applications. to ensure that the achievement of this project can be taken forward, backcrosses for all the targets have been generated and the seeds will be available for further introgression (table2).   
oil trait: at the university of york, we had used the same reverse genetic approach to develop high oleic hemp lines, the purpose being to obtain hemp oil with a longer shelf life and high omega3 line for increase health qualities. backcrossed homozygous lines were already available at the start of the project. a large field trial for the high oleic acid line was carried out within multihemp producing 28kg seeds which were used by wp5. a high omega 3 line was bulked ready for assessment by end users.   
the project has demonstrated the potential and limitations of using hdm to create new varieties in hemp and established a strong platform that will be of continuing value for hemp improvement.  
  
within multihemp, it is interesting to note that the potential targets identified by wp2 using forward genetic were two genes belonging to the same gene families as the ones selected in wp1. this confirmed that, in the area of cell wall properties, wp1 and wp2 reached similar conclusions. the tools and information generated within these wps could be potentially combined to validate conclusions. for example, our extensive transcriptomic work has confirmed that our target gene family members were highly expressed in fibre during development in comparison to other family members. it would be interesting to investigate if any of the wp1 target genes have been identified within the qtl generated by wp2 for lignin (cad) or decortication (pme). also, information on gene expression from wp1 could help select the most relevant genes within a qtl in wp2, and this would not be restricted to cell wall genes. there are also potential opportunities to complement the two genetic approaches with the work of wp4. no fibre quality analysis was carried out for our line because of a lack of material but wp4 data may provide insights on what define fibre quality which would lead to new targets for a reverse genetic approach  
table 1  
figure 1  
figure 2  
table 2  
  
wp2 genome-wide association mapping for hemp breeding  
objectives   
this wp supported the development of new hemp varieties optimized for different industrial processes resulting in bioproducts and biomass with an high added value. specific objectives of this wp were:  
â¢ characterization of the natural genetic and phenotypic diversity in hemp, represented here in a highly diverse collection of 100 hemp accessions, using a genome-wide association study.  
â¢ identify genes/qtls (or regions in the genome) underlying morphologic traits, such as plant height, number and length of the internodes and flowering time.  
â¢ identification of genes associated with the quality of hemp biomass such as fibre quality for different industrial applications.  
â¢ integrate this knowledge into existing and new hemp breeding programs to generate novel hemp varieties which can more efficiently be converted into biobased products.   
â¢ develop a set of tools for the breeding of hemp, both for genotyping and phynotyping.  
â¢ develop a pipeline for the generation of new hemp varieties for the different european environments and needs.  
  
after genotyping and phenotyping the 124 hemp accession of the mapping panel association mapping was performed to identify significant associations between 32,872 snp markers in the dna and important traits. in complex traits, such as e.g. âflowering timeâ, many genes are involved that all contribute to a certain (quantitative) extent to the outcome of the phenotype. regions in the dna (loci) associated with such traits are termed, quantitative trait loci (qtls). the outcome of traits is not only determined by the dna but is also influenced by the environment. association models can correct for the effect of environment (e) and interactions between environment and genotype (g x e). correcting for the environmental background effects can help to unmask qtls that have only a low effect on the trait in the mapping population (false negatives). however, in case of strong environmental effects, which is the case for hemp, a correction for environmental effects, is sometimes not fitting in an association model. also, correction for environmental effects may reduce relevant phenotypic variation caused by responses of regulatory genes to environmental stimuli.   
therefore, two strategies of association mapping were performed to detect significant phenotype x marker associations:   
1) mixed modeling per single location without correction for environmental background effects (genstat library, qsassociate, single environment, significance threshold -10log(p)>5) and,   
2) mixed modeling on multiple environments to correct for location effects (genstat library, qmassociate, multiple environments, significance threshold -10log(p)>4).  
  
in this way 1800 qtl regions were found with an snp marker in significant association to one or more of the complex traits, as phenotyped in one or more environments. subsequently, the genomic regions, scaffolds, harboring significant qtls were studied for the presence of candidate genes located in or nearby qtl region (expressed genes, mrna, in the cansat draft genome).  
in a first scan qtl regions for quality traits have been identified in the hemp cansat3 genome. genes in these qtl regions were studied for the presence of candidate genes. for instance the qua1/qua2 genes involved in pectin biosynthesis pathway, are likely candidate gene for fibre quality  
  
wp3 optimisation of hemp cultivation and crop modelling  
objectives  
the overall objective of wp3 is to carry out all field trials needed to support phenotyping of existing and improved genotypes and to evaluate the effect of genotype, environment and management (g x e x m) on yield and main quality traits. relevant data collected during trials in open field and controlled environment will be used to improve and parameterise a crop growth model that will be implemented with empirical and mechanistic relations to simulate the effect of environment and management on quality traits, and further to optimise g x e x m.  
specific objectives of wp3 are:  
â¢ characterisation of hemp varieties that are commercially available or in the phase of registration to identify their suitability for specific end-use destination;  
â¢ advances in agronomic practices to improve environmental sustainability and technical suitability of hemp cultivation for specific end use destinations;  
â¢ improve and parameterise a crop growth model to simulate and optimise the effect of g x e x m on fibre yield and quality and to aid hemp breeding  
  
in the frame of multihemp a very large number of field trials were carried out to study the effect of agronomic management (planting density, nitrogen fertilisation, harvesting time) and variety on yield and quality of hemp.  
two large multilocation trials (in italy, france, czech republic, the netherlands, latvia) were carried out in 2013 and 2016 with up to 16 commercial varieties. the difference in biomass yield among genotypes was large at all locations but mainly in southern locations where the largest difference of flowering times was recorded. the variation of stem and seed yield among genotypes was mainly determined by the difference in flowering time, which is under control of temperature and photoperiod. in late varieties stem ...

# MAGNUM BONUM

Project Acronym: MAGNUM BONUM

programme & topic: FP7-PEOPLE FP7-PEOPLE-2013-IOF

Most frequent returning words in objectives:

* ('firefighters', 8)
* ('differences', 6)
* ('uniforms', 6)
* ('skin', 5)
* ('layers', 5)
* ('design', 5)
* ('parameters', 5)
* ('impact', 4)
* ('electro-goniometers', 4)
* ('project', 3)
* ('protective', 3)
* ('minor', 3)
* ('firefightersâ\x80\x99', 3)
* ('subjective', 3)
* ('bulky', 3)
* ('designs', 3)
* ('subjects', 3)
* ('study', 3)
* ('suits', 3)
* ('concerns', 2)
* ('fire-fighter', 2)
* ('torsoâ\x80\x99s', 2)
* ('model', 2)
* ('textiles', 2)

this project concerns modelling of fire-fighter torsoâs skin model covered with a composite of three main layers of protective textiles (pts) working under simulated extreme external conditions. the reason why one initiated the work on this subject is the fact that pts are very important group of textiles that are life savers but the level of comfort when wearing them is low. thus, improving wearing comfort can support creation of better condition in relation human-outfit-environment. this project revolves around three main aspects:   
(a) modelling of mechanical and thermal finite element analysis (fea) of fire-fighter torsoâs skin model covered with a composite of three main layers of pts working under simulated extreme external conditions;   
(b) verification whether the minor differences in the design of uniforms and their fit can be quantified in terms of their impact on firefightersâ cardiorespiratory parameters and subjective perception of these uniforms;   
(c) measure a range of motion (rom) in firefighters to observe whether it can be restricted by wearing stiff and bulky clothing.  
  
in order to address some of these aspects fea of firefightersâ skin and avatars covered by a composite of three main layers of pts were created. in the current stage of the project, the main focus is on the finite element analysis that concerns human tissue (skin and muscles) and the textile composite in contact with each other as well as a skin compression under the influence of the textile composite. this is a very challenging task as each of the elements (instances in abaqus cae) that were supposed to be modeled must have been presented in a different scale   
 (figures 1,2,3 & 4).  
the impact of minor design improvements compared to the existing designs of ppc is still relatively difficult to quantify due to the lack of sensitive devices used in smart measuring methodologies; however, the perception of these slight differences is reported by ppc users. the impact of these design differences in ppc on firefighters was studied via physiological tests based on occupation-related activities in which cardiorespiratory parameters were monitored and three-dimensional (3-d) silhouette scanning was performed on the firefighters. apart from heart rate (beats/min), none of the other measured physiological parameters, for example, oxygen consumption (vo2, ml/min) demonstrated statistically significant differences when firefighters were testing uniforms: ergonomic (er), standard (st), bulky (bu), and reference outfit (ro), the latter being t-shirt and shorts. a statistically significant correlation was found between parameters measured via 3-d body scanning and selected cross-sections of the silhouettes as well as subjective assessments of easiness of specific movement performance during the physiological test and assessment of bulkiness of the uniforms. there is a limited influence of the minor design differences between firefightersâ uniforms on the selected physiological parameters of the subjects wearing them. the outcome of the study can be utilized when performing the test on subjects and improving designs of ppc (figure 5,6,7 & 8).  
  
the rom, which is unassisted and voluntary motion of joints, is assessed by goniometers or electro-goniometers when subjects are wearing and testing different outfits.the rom can be restricted by wearing stiff, bulky, and uncomfortable clothing.   
this is particularly true of firefighter suits that are constructed using fabric layers to provide thermal protection from fire. this study developed an evaluation technique to quantify the loss of mobility associated with wearing firefighters' protective suits that were deliberately selected to represent similar ergonomic design features. the rom of ten firefighters was measured using electro-goniometers attached to their bodies while they wore uniforms and the ro, and performed specific movements. the most restrictive uniform is the bu suit that contained additional layers of materials in sleeves and on the knees. the st was more rom restrictive than er. the subjective evaluation of suits supported the objective assessments provided by the electro-goniometers. a 3-d body scanning technique was employed to establish a correlation between the bulkiness of firefighter outfits and subject rom. practitioner summary this study presents a methodology for measurements of rom in firefighters wearing personal protective equipment (ppe). even small differences in designs of ppe may impact firefighters' rom, which can be detected by electro-goniometers providing measurements if they are attached along the joint to measure limb angular movement (figure 9,10).

# FlowMat

Project Acronym: FlowMat

programme & topic: FP7-PEOPLE FP7-PEOPLE-2013-CIG

Most frequent returning words in objectives:

* ('drop', 10)
* ('work', 10)
* ('fipi', 9)
* ('method', 7)
* ('particles', 6)
* ('textiles', 6)
* ('project', 5)
* ('fluid', 5)
* ('experiments', 5)
* ('dynamics', 5)
* ('drops', 5)
* ('penetration', 5)
* ('impact', 5)
* ('interfaces', 4)
* ('liquid', 4)
* ('research', 4)
* ('analysis', 4)
* ('multiphase', 3)
* ('years', 3)
* ('fast', 3)
* ('interface', 3)
* ('particle', 3)
* ('interaction', 3)
* ('simulation', 3)

summary of the project   
  
flowmat has explored new ways in which fluid interfaces and capillarity can be exploited in the field of materials science. the overarching objective of the project is to combine continuum simulations, mathematical modelling, and experiments to investigate the behaviour of multiphase flow mixtures featuring solid particles that adhere to fluid interfaces, the dynamics of drop deposition processes, and the mechanics of anisotropic colloids interacting with fluids or fluid interfaces.   
  
over the past four years we have been developing the fast interface particle interaction (fipi) method. this is a conceptually new numerical method that allows the accurate simulation of thousands of particles interacting with fluid interfaces on a common pc. the method can be used to investigate numerous applied problems, from the optimization of the state of dispersion in multiphase polymer blends to drop generation in microfluidic devices. in the second period of the project we have completed a publication exploring the use of fipi to study a pendant drop experiment, further validated the code, and applied fipi to simulate the buckling dynamics of particle-covered drops.  
  
in collaboration with a government defence agency (the uk defence science and technology laboratory) we have investigating experimentally mechanisms of spreading in nominally omniphobic textiles. such textiles defend soldiers in the field to potential chemical attacks. in the second period of the project, we have carried out x-ray measurements of the penetration of the liquid inside the textile and started working on optical experiments on drop impact on textiles (collaboration with dr. r. castrejon-pita).   
  
we have started a new research line on the modeling of elastic deformations of plate-like thin colloids in flow. the preliminary work we have carried out has enabled the researcher to develop a starter grant proposal for the europear research council (erc) on the hydrodynamics of suspended graphene and other 2d nanomaterials. the proposal has been awarded funding by the erc, and has started in apr. 2017.   
  
scientific achievements   
  
the most prominent advancement in the past 4 years has been the development of the fast interface particle interaction (fipi) method. we have developed fipi from scratch. this has taken about 1.5 years. we have then applied the fipi method to the problem of analyzing the surface stress on a pendant drop whose surface is covered with colloidal particles. the analysis was carried out both for static drops and for drops that pinch off. the work has resulted in a publication on soft matter. the work is the first analysis of a pendant drop simulation in which the quasi-solid surface layer is not treated as a continuum. we have then applied fipi to the simulation of a drop covered with particles, to examine the conditions for which the drop sheds particles vs. the condition leading to drop buckling. the work is currently under review in soft matter.   
  
we have carried out an experimental analysis of liquid pendentration inside a textile. our work is pioneering: we have been able to visualise the microscopic dynamics of penetration across the textile (in the thickness direction), using oils with ultralarge viscosity to slow down the penetration process. no published work has given accurate data on the normal liquid penetration in textiles, so our work is expected to have significant scientific and technological impact. the work has been published on langmuir.   
  
we have carried out the first numerical analysis of exfoliation by âhydrodynamic peelingâ, a microscopic process of relevance to the production of graphene on industrial scales. the work is currently under review.   
  
expected results and impact   
  
this cig-funded project has produced 4 main impact results.  
  
- a new numerical method has been developed: the fast interface particle interaction (fipi) method. fipi has received quite a lot of attention from researchers interested in the dynamics of multiphase fluid-fluid systems with suspended particles. colleagues from tsinghua university (china) and university of arkansas (usa) have requested a copy of the software for their research.   
- pioneering high-resolution experiments on drops interacting with textiles have been carried out. we have characterised liquid penetration in textiles using dynamic x-ray experiments, and are currently examining drop impact experiments using high-speed imaging.  
- funding from the cig has enabled the fellow to initiate a research line on hydrodynamics of graphene suspension that has led to an erc starter grant and a promotion to senior lecturer as a result.   
- the fellow has collaborated with researchers from university of twente on the dynamics of drops deposited on viscoelastic layers. the work has resulted in joint publications in the journal of fluid mechanics and pnas.

# GREEK TEXTILE TOOLS

Project Acronym: GREEK TEXTILE TOOLS

programme & topic: FP7-PEOPLE FP7-PEOPLE-2012-IEF

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* ('spindle', 8)
* ('whorls', 8)
* ('wool', 8)
* ('animal', 6)
* ('evidence', 6)
* ('areas', 6)
* ('siennicka', 6)
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during the project, the relevant published and unpublished archaeological data regarding textile manufacture was systematically collected and analysed. the fieldwork was carried out in the archaeological museums and excavations depots in greece (argos, tiryns, nemea, corinth, athens, kolonna) and was supplemented with thorough bibliographical queries. as a result, extensive data set about eba textile tools (primarily spindle whorls and loom weights), was gathered, documented (described, drew, photographed, weighed, measured), examined macroscopically in order to explore manufacture and use ware traces, and analysed.   
to the main results of the project belongs a comparative study of textile tools from several important eba south greek sites and a discussion on cultural changes and continuity in greece. particularly interesting was the transitional period of eba ii and eba iii, seen through the appearance and distribution of textile tools and new technologies. it was examined when the first appearance, distribution and spread of new techniques in textile manufacture in greece took place, and whether they were influenced or introduced by various cultures and peoples.   
a particular emphasis was put on the use of plant (flax) and animal (mainly sheep wool) fibres, and potential consequences of the introduction of woolly wool in greece in the eba, which undoubtedly revolutionised textile production in prehistory. the most ancient fibres used for textile making were bast fibres with flax, hemp and nettle; also tree bark fibres to produce cordage and rope may have been used since the paleolithic period. there is solid archaeobotanical evidence for the use of flax at many sites in greece in the neolithic and eba. flax was possibly used to extract oil, nevertheless, its widespread presence indirectly indicates the use of the plant in textile manufacture. as far as animal fibres are concerned, goat and sheep hair and wool may have been known already in the neolithic, but the wool was hairy, short and coarse, and as such never played the major role in textile manufacture. it was previously suggested by other scholars, and recently confirmed by the extensive study of the topoi group in berlin under prof. c. becker that long-staple wool (woolly wool), suitable for spinning with spindle whorls, first appeared in greece during the 3rd millennium bc. this research project concluded, however, that it is not possible to prove this hypothesis through the use of particular textile implements, like spindle whorls. no clear shift in the use of spindle whorls (from heavy to light), which would suggest that woolly wool was rapidly and broadly employed, could be identified. this is one of the main results of the study that eba greek textile implements do not seem to reflect a fundamental change in textile making. even if woolly wool was clearly more advantageous than plant fibres, it either needed considerably more time to gain importance, or is not visible in the archaeological record. the archaeological, archaeozoological, archaeobotanical and ethnographical evidence collected during the project, as well as results of experiments and tests suggests that in eba greece plant fibres remained popular throughout the entire 3rd millennium bc.   
  
experimental tests with copies of spindle whorls and loom weights from greek sites, undertaken mainly in copenhagen (centre for textile research, university of copenhagen) and in warsaw (institute of archaeology, university of warsaw), also addressed the question of fibres types: the examined spinning tools proved to work very well both with animal and plant fibres. nevertheless, the large and heavy spindle whorls (up to 120 g), popular particularly in the eba ii period, were probably used for plying threads, yet spinning of coarse plant fibres, perhaps for making outdoor cloths and domestic textiles (like blankets and rugs) was also possible.   
the tests also investigated weaving techniques, and helped reconstructing various weaves potentially used in eba greece. well attested loom weights belonged to a cylindrical type, with one, two or (seldom) three lengthwise perforations; also examples without holes â the so-called spool-shaped (cf. siennicka, ulanowska 2016) are frequent. it was demonstrated (siennicka, ulanowska 2016) that the latter were suitable for various textile-related activities, like warping, storing thread, and weaving (as loom weights or in tablet weaving). at tiryns, a site of great importance for the eba in the peloponnese, which witnessed multiple influences and exchange with distant areas, additional types of loom weights were identified (cf. siennicka 2012; siennicka submitted): large cones and crescent-shaped loom weights, almost unknown in greece of this period. the experimental tests helped to reconstruct the weaves and fabrics possibly produced with them (cf. ulanowska in press). the primary type of weave used in the prehistory was tabby (plain weave), however, this research combined with the experiments inspired by the recent paper of a. wisti lassen (2013), suggests that in eba greece, a diagonal weave â twill â might have been produced with crescent-shaped loom weights discovered at tiryns. all weaving implements (cones, cylinders, crescent-shaped objects, and clay spools), were suitable to produce weft-faced and balanced plain weaves (tabbies), appropriate both for ordinary and outdoor clothes, as well as for making domestic textiles, like blankets or rugs. the majority of the loom weighs were heavy (400-500 g, and more), therefore, coarse textiles seem to be frequently produced on warp-weighted looms during this period.   
finally, social and economic issues of textile making were addressed, like gender issues and defining working areas and modes of production in eba greece. it was demonstrated that textile manufacture was a crucial and very widespread activity, and was undertaken in many of the eba settlements, both outdoors and indoors, while specialised workshops were not common at that time (siennicka in press; ulanowska, siennicka in press). working areas for yarn preparation were recognised in eba settlements. the household based manufacture was predominating, while the wide range of shapes and masses of spindle whorls suggests that the eba thread producers were skilled to prepare varied yarns, from very fine to coarse, and they probably used different spindle whorls for specific fibres (plant or animal). specialisation of yarn production in the individual households was suggested, therefore individual or household industry production mode can be assumed. weaving was performed mainly in domestic areas. more organised manufacture, especially during eba ii, cannot be ruled out as the evidence from lerna suggests. nevertheless, the poor quality of loom weights and their great diversity in shapes and masses suggest that weaving was mainly a domestic and non-specialised occupation. textile production played an important role in the socio-economic life of eba societies. manufacture of fabrics and clothes, and use of plant and animal fibres may have been at least partly controlled by the eba chiefdoms, as was the case in contemporary near eastern societies. textile implements, techniques and fibres could have been introduced and/or imported from distant areas, e.g. from anatolia as finds of e.g. crescent-shaped loom weights at tiryns suggest. the evidence of eba textile craftspeople is still vague, particularly as far as the gender issues are concerned, but the project was able to improve our knowledge of this socially and economically important craft.   
  
the project produced significant new insights into the economic and social importance of textiles. a new tool for the archaeologists to analyse archaeological evidence for textile production in greece was established and it provides a framework both for the re-evaluation of the extensive material excavated since the 19th century, and for recent and future discoveries. it adds greatly to the common understanding of the early development of textile production, which was undoubtedly a crucial craft of mankind. the research is relevant for historians, archaeologists, anthropologists, ethnographers, textile historians, textile experts, the tourism sector and craftspeople, as well as for all people who are interested in human past and human achievements.

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during the project, the relevant published and unpublished archaeological data regarding textile manufacture was systematically collected and analysed. the fieldwork was carried out in the archaeological museums and excavations depots in greece (argos, tiryns, nemea, corinth, athens, kolonna) and was supplemented with thorough bibliographical queries. as a result, extensive data set about eba textile tools (primarily spindle whorls and loom weights), was gathered, documented (described, drew, photographed, weighed, measured), examined macroscopically in order to explore manufacture and use ware traces, and analysed.   
to the main results of the project belongs a comparative study of textile tools from several important eba south greek sites and a discussion on cultural changes and continuity in greece. particularly interesting was the transitional period of eba ii and eba iii, seen through the appearance and distribution of textile tools and new technologies. it was examined when the first appearance, distribution and spread of new techniques in textile manufacture in greece took place, and whether they were influenced or introduced by various cultures and peoples.   
a particular emphasis was put on the use of plant (flax) and animal (mainly sheep wool) fibres, and potential consequences of the introduction of woolly wool in greece in the eba, which undoubtedly revolutionised textile production in prehistory. the most ancient fibres used for textile making were bast fibres with flax, hemp and nettle; also tree bark fibres to produce cordage and rope may have been used since the paleolithic period. there is solid archaeobotanical evidence for the use of flax at many sites in greece in the neolithic and eba. flax was possibly used to extract oil, nevertheless, its widespread presence indirectly indicates the use of the plant in textile manufacture. as far as animal fibres are concerned, goat and sheep hair and wool may have been known already in the neolithic, but the wool was hairy, short and coarse, and as such never played the major role in textile manufacture. it was previously suggested by other scholars, and recently confirmed by the extensive study of the topoi group in berlin under prof. c. becker that long-staple wool (woolly wool), suitable for spinning with spindle whorls, first appeared in greece during the 3rd millennium bc. this research project concluded, however, that it is not possible to prove this hypothesis through the use of particular textile implements, like spindle whorls. no clear shift in the use of spindle whorls (from heavy to light), which would suggest that woolly wool was rapidly and broadly employed, could be identified. this is one of the main results of the study that eba greek textile implements do not seem to reflect a fundamental change in textile making. even if woolly wool was clearly more advantageous than plant fibres, it either needed considerably more time to gain importance, or is not visible in the archaeological record. the archaeological, archaeozoological, archaeobotanical and ethnographical evidence collected during the project, as well as results of experiments and tests suggests that in eba greece plant fibres remained popular throughout the entire 3rd millennium bc.   
  
experimental tests with copies of spindle whorls and loom weights from greek sites, undertaken mainly in copenhagen (centre for textile research, university of copenhagen) and in warsaw (institute of archaeology, university of warsaw), also addressed the question of fibres types: the examined spinning tools proved to work very well both with animal and plant fibres. nevertheless, the large and heavy spindle whorls (up to 120 g), popular particularly in the eba ii period, were probably used for plying threads, yet spinning of coarse plant fibres, perhaps for making outdoor cloths and domestic textiles (like blankets and rugs) was also possible.   
the tests also investigated weaving techniques, and helped reconstructing various weaves potentially used in eba greece. well attested loom weights belonged to a cylindrical type, with one, two or (seldom) three lengthwise perforations; also examples without holes â the so-called spool-shaped (cf. siennicka, ulanowska 2016) are frequent. it was demonstrated (siennicka, ulanowska 2016) that the latter were suitable for various textile-related activities, like warping, storing thread, and weaving (as loom weights or in tablet weaving). at tiryns, a site of great importance for the eba in the peloponnese, which witnessed multiple influences and exchange with distant areas, additional types of loom weights were identified (cf. siennicka 2012; siennicka submitted): large cones and crescent-shaped loom weights, almost unknown in greece of this period. the experimental tests helped to reconstruct the weaves and fabrics possibly produced with them (cf. ulanowska in press). the primary type of weave used in the prehistory was tabby (plain weave), however, this research combined with the experiments inspired by the recent paper of a. wisti lassen (2013), suggests that in eba greece, a diagonal weave â twill â might have been produced with crescent-shaped loom weights discovered at tiryns. all weaving implements (cones, cylinders, crescent-shaped objects, and clay spools), were suitable to produce weft-faced and balanced plain weaves (tabbies), appropriate both for ordinary and outdoor clothes, as well as for making domestic textiles, like blankets or rugs. the majority of the loom weighs were heavy (400-500 g, and more), therefore, coarse textiles seem to be frequently produced on warp-weighted looms during this period.   
finally, social and economic issues of textile making were addressed, like gender issues and defining working areas and modes of production in eba greece. it was demonstrated that textile manufacture was a crucial and very widespread activity, and was undertaken in many of the eba settlements, both outdoors and indoors, while specialised workshops were not common at that time (siennicka in press; ulanowska, siennicka in press). working areas for yarn preparation were recognised in eba settlements. the household based manufacture was predominating, while the wide range of shapes and masses of spindle whorls suggests that the eba thread producers were skilled to prepare varied yarns, from very fine to coarse, and they probably used different spindle whorls for specific fibres (plant or animal). specialisation of yarn production in the individual households was suggested, therefore individual or household industry production mode can be assumed. weaving was performed mainly in domestic areas. more organised manufacture, especially during eba ii, cannot be ruled out as the evidence from lerna suggests. nevertheless, the poor quality of loom weights and their great diversity in shapes and masses suggest that weaving was mainly a domestic and non-specialised occupation. textile production played an important role in the socio-economic life of eba societies. manufacture of fabrics and clothes, and use of plant and animal fibres may have been at least partly controlled by the eba chiefdoms, as was the case in contemporary near eastern societies. textile implements, techniques and fibres could have been introduced and/or imported from distant areas, e.g. from anatolia as finds of e.g. crescent-shaped loom weights at tiryns suggest. the evidence of eba textile craftspeople is still vague, particularly as far as the gender issues are concerned, but the project was able to improve our knowledge of this socially and economically important craft.   
  
the project produced significant new insights into the economic and social importance of textiles. a new tool for the archaeologists to analyse archaeological evidence for textile production in greece was established and it provides a framework both for the re-evaluation of the extensive material excavated since the 19th century, and for recent and future discoveries. it adds greatly to the common understanding of the early development of textile production, which was undoubtedly a crucial craft of mankind. the research is relevant for historians, archaeologists, anthropologists, ethnographers, textile historians, textile experts, the tourism sector and craftspeople, as well as for all people who are interested in human past and human achievements.

# BETITEX

Project Acronym: BETITEX

programme & topic: FP7-SME SME-2013-2

Most frequent returning words in objectives:

* ('textile', 50)
* ('textiles', 34)
* ('biocide', 31)
* ('bedbugs', 27)
* ('project', 26)
* ('ticks', 24)
* ('betitex', 22)
* ('clothing', 21)
* ('figure', 20)
* ('biocides', 18)
* ('application', 18)
* ('market', 18)
* ('materials', 15)
* ('smes', 14)
* ('products', 14)
* ('europe', 14)
* ('protective', 13)
* ('sol-gel', 13)
* ('fabrics', 13)
* ('protection', 12)
* ('order', 12)
* ('sector', 11)
* ('effect', 11)
* ('impact', 11)

executive summary:  
betitex is a research and development project, cofounded by the european union's seventh framework programme (fp7/2007-2013) under grant agreement nâº 606517, starting on november 2013 and lasting 36 months.  
  
its aim is to obtain textile materials capable of providing protection against ticks and bedbugs, arthropods of medical and veterinary importance all over the world, in order to solve the current lack of protective solutions.   
  
it is coordinated by gremi tãxtil de terrassa, a non-profit catalan organization which joins more than 120 companies in the textile sector. in betitex, gremi leads a consortium of 10 partners: 3 textile associations (ateval from spain, clutex from czech republic and texclubtec from italy); 3 technological centers (inotex from czech republic and leitat and tecnalia both from spain; 4 smes (gemâinnov from france, nilka from turkey and silk&progress from czech republic and liasa from spain).  
  
the research and development activities carried out are focused on:  
  
1. study and selection of the biocides and the textile materials where to be applied.  
  
2. study and define the incorporation of the biocides to the textile materials. the selected technologies are: microencapsulation and application of microcapsules by finishing processes, during the extrusion and sol-gel technology.  
  
3. develop and validate test methods of biological effectiveness  
  
4. application of the biocides to textile materials   
  
5. determination of the durability of the biocide effect  
  
6. industrialization of the optimal solution  
  
these tasks have been structured in a work plan consisting on five r&d work packages and one demonstration work package.  
  
in order to assure the communication of the project and its results to the general public, scientific community and other stakeholders and the correct management of the project, two transversal work packages have been carried out during the whole project: dissemination and management.  
  
the final betitex result is a prototype of a textile material: efficient, environmentally friendly and with a slow release of biocide. this prototype will be the base for new final products such as mattress covers or other home textiles protecting against bedbugs and also garments for outdoor activities protecting against ticks.  
  
project context and objectives:  
other arthropods, increased restrictions on the use of pesticides, climate change and other anthropogenic factors (e.g. changes in agricultural practices).  
  
vectors are living beings which carry and transmit infectious pathogens to other living organisms.  
  
according to the who - world health organization, vector-borne diseases account for over 17% of all infectious diseases, and cause every year more than 1 million deaths.  
  
some of the resurging vectors are mosquitoes, lice, ticks and fleas.  
  
figure 1 shows the presence of ixodes ricinus (common tick) in europe. an increase is observed from 2012 to 2016, especially in the countries of central europe.  
  
figure 1: presence of ixodes ricinus in europe  
source: european center for disease prevention and control (ecdp)  
  
ticks are small arachnids that feed on blood. they are found mainly in habitats with vegetation, maintaining high humidity, such as woodlands.   
  
they are involved in the transmission of a variety of pathogens of major medical and veterinary importance. two of the major diseases transmitted by the common tick are:  
  
- lyme borrellosis (lyme disease): is the main tick-borne disease in europe. it can affect the nervous system. 10% of infected people may develop disorders in the central nervous system.  
  
- tick-borne encephalitis (tbe): is a viral infection that causes brain inflammation in 25% of infected people. russia and europe report between 10,000 and 12,000 cases of infections in humans each year.  
  
other arthropods in resurgence are bedbugs, insect parasites of the cimicidae family that feed exclusively on blood. the common bedbug is the cimex lectularius.  
the increased presence of bedbugs is attributed to increased international travel, climate change, mismanagement of insecticides and the development of insect resistance to insecticides (mainly pyrethroids).  
  
bedbugs are suspected of transmitting infectious agents. there is international concern about their vectorial capacity (about 40-45 pathogens have been detected in wild bedbugs and/or lab bedbugs), some as important as chagas disease or hepatitis b. however, no data exists demonstrating their efficient transmission under natural conditions.  
  
bedbugs can reduce the quality of life, causing anxiety, discomfort, skin disorders, insomnia, anaemia (when many) and may even cause anaphylaxis. they have a great negative impact on tourism at world level.  
  
the habitats of the bedbugs are especially sofas, mattresses and other furniture.   
  
in spain, the most demanded bedbug pest control services are distributed as shown in figure 2.  
  
an example of the resurgence of bedbugs in the united states is shown in figure 3. since 2000 until today, the presence of bedbugs has increased up to 70%.  
  
figure 2: distribution of services required for bedbugs pest control   
source: national association of pest control (anecpla)  
  
figure 3: evolution of the presence of bedbugs in the united states  
source: hilton head exterminators   
  
bedbugs and ticks, despite being present in different habitats, have similar behavior and are affected by the same type of biocide.  
  
nowadays the most used method to fight them is using a repellent-spray. these sprays contain the biocides responsible of providing protection to the user. there are not too many authorized repellents by the regulation (eu) no 528/2012. many known active substances are not accepted in the european market due to their toxicity and/or their environmental impact.   
  
to solve the current lack of protection against bites of these two types of arthropods, the betitex project was conceived.  
  
main betitex objectives are:  
  
â¢ to develop functional textiles with protection against ticks and bedbugs, mainly for outdoor garments and home textiles.  
  
â¢ to develop and research on environmentally friendly biocides offering protection against ticks and bedbugs and accepted by the regulation (eu) no 528/2012.  
  
â¢ to develop innovative finishing technologies (sol-gel, microencapsulation and extrusion) in order to control the repellent effect and so contributing to a longer lifespan (control-release of the biocide).  
  
â¢ to obtain high durability of the finishing (maintaining the repellence property at least up to 50 washings) by biocide control release (long-lasting biocide treated textiles)  
  
â¢ to reduce the use of repellent sprays that are used nowadays (spreading them on the human body).  
  
â¢ to promote the betitex results by the sme-associations involved in the project to their smes associated companies, in the textile sector.  
  
â¢ to offer solutions to the smes and improve their competitiveness by getting protective textiles against ticks and bedbugs in the field of outdoor garments and home textiles.  
  
project results:  
betitex project research activities have been structured in five r&d work packages and one demonstration work package. figure 4 shows the project workplan.  
  
figure 4. betitex workplan  
  
wp1. study and selection of the materials  
  
1. study and selection of biocides  
  
there are a wide variety of biocide products all over the world. environmental disturbances and public health risks derived from abuse of pesticides are constant alerts that demand innovative researches. in this sense, this task had the aim to select the biocides between accepted ones, by regulation (eu) no 528/2012.  
  
the selection has been divided in two main tasks: an initial selection of biocides in which a bibliographic review of selected chemicals known to have repellent and/or insecticidal effects on ticks /bedbugs all over the world has been done. for the final selection, the bibliographically pre-selected biocides (with repellent effect (pt19) and insecticidal effect (pt18)) have been evaluated against bedbugs and ticks in the laboratory, though in vitro feed screening tests.  
  
three repellents and three insecticides were selected.  
  
2. study and selection of textile raw materials  
  
in this task, the textile materials to be used as raw materials in the following work packages have been selected.  
  
the selection process began with a study on the presence, habitat, hazards, etc. of bedbugs and ticks.   
  
as a result of this study the major application sectors have been selected: clothing for outdoor activities and personal protective clothing (protection against ticks) and home textiles (protection against bedbugs).   
  
from these sectors, the most commonly used textile materials have been studied, in terms of raw materials and structures, with a final selection of four substrates.  
  
wp2. study and definition of the biocides incorporation on textiles  
  
in this wp, different methodologies for including the previously selected biocides into the selected fabrics have been studied.  
  
these technologies include:  
  
1. embedding technologies of the biocide: sol-gel coating and micro and nanoencapsulation of the biocide.  
  
the sol-gel technology consists of a series of hydrolysis and condensation reactions, whereby one solution (sol-gel) containing the biocide inside is obtained. it is a method well known to provide new functionalities to materials.  
  
the main advantage of insecticide/repellent textiles by sol-gel coatings is the control over the amount of insecticide/repellent into the silica coating and the excellent adhesion of sol-gel coating to the textile fibres due to the nanoparticulate size of the sol particles.  
  
the micro/nano encapsulation (depending on the size of the capsule) is a process by which the active ingredient (in this case the biocide) is wrapped with a protective layer (shell) that allows a controlled release.   
  
the need for biocides encapsulation is mainly based on their toxicity for both human or animals and the environment. although isolation of the insecticide is required regarding health issues, proper and controlled release in the target has to be performed to achieve the active effect. thereby, the main challenge for selected polymer matrix or shell is the matching of compromise between a good protection of biocide and an appropriate liberation of product at the correct dosage. additionally, controlled release of biocide may result in a reduction in resistance of bugs or ticks, providing an added value.  
  
the concern of minimizing the contact between biocides and human skin or environment has been growing in the last years and different encapsulation approaches have been studied and evaluated.  
  
2. application of the embedded biocide onto textile materials. two different technologies have been studied: finishing technologies and extrusion.  
  
the finishing technologies selected are: padding, coating and exhaustion. the extrusion process consists on the incorporation of the micro or nanoencapsulated biocide in a polypropylene yarn during its extrusion.  
  
the usual problem in the application of biocides on the fabrics is low durability of their biological efficacy after washing. for that reason, the efforts have been focused on finding new methodologies characterized by a slow release of the biocide from the textile and a high resistance to washing.   
  
as final result, a definition and description of the potential processes to be followed according to the biocides and fabrics selected has been obtained.  
  
wp3. development and validation of biological effectiveness test methods  
  
the goal of this workpackage is to study and define the methodology for testing fabrics with effect against ticks and bedbugs.  
  
first task of the wp was the laboratory in-vitro cultures (ixodidae and cimicidae). second task was the development of the methodology to assess antitick and antibedbug properties of the biocide treated textile materials.  
  
cimex lectularius l. was selected as the cimicid target of the betitex project for its worldwide distribution and its high signification as manâ´s parasite because of its strong semisynanthropic habits. c. lectularius is a hemimetabolous insect that requires vertebrate blood in all five nymphal instars as well as in the adult stage. original hosts of bed-bugs are bats, but they have evolved switching to other vertebrate species, including man.  
  
figure 5. cimex lectularius l.  
  
ixodes ricinus was selected as it is the most widespread and abundant ixodid tick in western europe and frequently bites humans. it is an important vector of zoonotic diseases, including lyme disease, tick borne encephalitis, ehrlichiosis and babesiosis (bonnet et al, 2007).  
  
figure 6. ixodes ricinus  
  
wp4. application of biocides and characterization  
  
this wp consists on the application of the selected biocide onto the selected textile materials by using the selected methodologies, at laboratory scale.  
  
the wp is divided in three main tasks:  
  
1. sol-gel formulation and application: development of a sol-gel formulation containing a repellent and/or insecticide: studying type of precursor, ph, water/alkoxide ratio, type of catalyst, solvent, time and temperature and amount of insecticide/repellent.  
  
the sol-gel formulation has been applied onto the textile material by padding.  
  
figure 7. sol-gel process  
  
1. microcapsules development and application on textiles  
  
the micro/nanoencapsulation process avoids the degradation of the core, masks odours, protects the core during the processing and allows controlled-release of the active substance.  
  
the three types of encapsulation used are: sol-gel nanocapsules, in-situ polymerization and interfacial polymerization.  
  
figure 8. microcapsules on cotton fibers  
the obtained micro and/or nanocapsules have been incorporated onto textiles by: padding, exhaustion and coating, and within a polypropylene yarn.  
  
once introducing microcapsules in a formulation, different parameters have to be studied such as the dispersion level, the stability of the dispersion, the concentration of microcapsules and the concentration of the binder.  
  
the concentration of the microcapsules applied on the fabric has also to be controlled in order to employ the minimum quantity of microcapsules necessary to obtain a good effectiveness and a good washing fastness of the effect.  
  
the padding process consists of introducing the solution containing the insecticide inside the padding machine and the fabric is squeezed between the machine rolls after being impregnated in the solution. then the textiles are dried and cured in a stenter.  
  
the coating process can be done by foaming or not the solution. in foam coating the application on the fabric is done by a knife coating machine. after application on the fabric, the textile is dried and cured to fix the finishing layer on its surface.  
  
the exhaustion process consists in immersing the fabric inside a solution containing the insecticide during a specific period of time and at a specific temperature profile, until exhausting the bath. the fabric is also submitted to agitation to enhance its impregnation into the bath. then, the textiles are finally dried.  
  
the process of applying the micro/nanocapsules within the polypropylene yarn is shown at figure 9.  
  
 figure 9. incorporation of micro/nanocapsules containing biocide on a polypropylene yarn  
  
figure 10. diagram of the application processes which have been carried out in wp4  
  
3. characterization  
  
the obtained fabrics and yarns have been characterized according to the tests shown in figure 11, in order to determine the biocide content on the micro/nanocapsules, once they have been applied onto the textile materials, their structure and also the main properties of the fabrics to confirm they maintain their initial properties (before being treated).  
  
figure 11. characterization tests  
  
wp5. determination of durability and optimization  
  
the objective of this wp is to determine the effectiveness of biocide by means of repellency and mortality tests (according to the biocide used) conducted adapting methodologies to betitex project (previously defined in wp3).  
  
effectiveness has been determined without washing and then with 1, 5, 25 and 51 washes, as this is one of the weaknesses of the technologies used.  
  
moreover, a complete characterization of the fabrics according final fabric application has been done in order to define if the optimum fabric is capable of providing with biocide effect without reducing common and usual characteristics.  
  
the different research lines studied in wp4 have been further evaluated aiming to determine the most feasible options to be transferred to industrial scale in wp6.  
  
figure 12. mortality tests  
  
figure 13. repellence tests  
  
on the other hand, due to the different end uses of the products developed, it is necessary to determine the complementarity of the biocide application processes with other necessary finishes depending on application.  
  
functional clothing is relatively new and a growing segment of the textile clothing group. the field of functional clothing is wide and diverse with each functionality having its own specification, material requirements, consequent technologies and processes. all clothing is known to perform multiple functions from aesthetic to basic protection from the external environment elements and respect of users comfort.  
  
functional clothing can therefore be defined as a generic term related to both - clothing or assemblies that are specifically engineered to deliver various predefined performances or functionality to end user who goes over its normal function. standard classification used for technical textiles divides the textiles to the three basic groups: protective, medical, sports/outdoor textiles. the protective â functional presents the largest segment of functional clothing (ppe) â one of highlighted. more and more the (multi)functional textiles penetrate in o the b2b (barrier) textiles for technical uses as well.  
  
the textile industry is constantly striving for innovative production techniques to improve product quality. besides the traditional function by dressing people, textiles now provide wear comfort and protection in dangerous environments. textile finishing chemicals are used to convert a textile material into a technical textile with functional properties. in the textile industry, finishing is usually carried out in the final stage of textile processing, as a result of which the textiles gain several functional characteristics. novel finishes providing high value addition to textile fabrics are greatly appreciated by a more demanding consumer market. the functional finishes can also be applied to apparel fabrics, household textiles and technical textiles to increase their attractiveness to the consumer and to stimulate growth at the niche markets.  
  
there are different types of functional finishes and the right type of finish should be decided depending on the fibre type of the textile substrate and the desired end use. the additional costs of the multifunctional textiles must be compensated by durability of functional effects. more and more the (multi)functional finishing processes work together with the maintenance service processing.  
  
the multi-functionalization has been tested with hydrophobic finish and antibacterial finish.  
  
finishes that repel water are important in all categories of the textile market. hydrophobic finishes give additional properties on fabrics to realize higher value textile products. repellence properties also enable easier cleaning of fabrics.   
  
the growth of microorganisms on textiles leads to the generation of unpleasant odour, discoloration of the fabric and reduction in the fabric strength and other useful properties. for these reasons, it is highly desirable that the growth of microorganisms on textiles is minimised during their storage and use.   
  
after the application of the multifunctional treatments, effectiveness tests have been carried out in order to determine which is the final effect.  
  
wp6. industrialization of the optimal solution: microencapsulation, finishing and extrusion  
  
the last stage of the project involves the industrialization of the optimal solution obtained in the previous wp, at the premises of the participating smes in the project.  
  
various microcapsulesâ types have been developed and characterized (particle size and spherical form). the capsules prepared have been compared to the capsules obtained at laboratory scale. the presence of the biocide has been determined as well after the microencapsulation process.  
  
from one side, these microcapsules have been used for the production of a biocide yarn and, from the other side, they have been applied onto textiles by the mentioned finishing processes.  
  
figure 14. industrialization scheme  
  
final results of the betitex can be summarized as follows:  
  
- functional textile material with protection against ticks and bedbugs for ppe â personal protective equipment and home textiles applications.  
  
- use of environmentally friendly biocides offering protection against ticks and bedbugs which are accepted by the regulation (eu) no 528/2012 of the european parliament and of the council of 22 may 2012 concerning the making available on the market and use of biocidal products.  
  
- use of innovative finishing technologies (sol-gel, microencapsulation and extrusion) in order to control the repellent effect and so contributing to a longer lifespan (control-release of the biocide).  
  
- obtaining high durability of the biocide effect (maintaining the biocide property at least up to 50 washings) by biocide control release (long-lasting biocide treated textiles).  
  
in general terms, and according to the market research on available similar products on the market, results of effectiveness achieved are considered as satisfactory.  
  
potential impact:  
socio-economic impact  
  
betitex has been carried out by a consortium mainly set up of textile organizations: textile trade associations, technological centers and smes.  
  
in that sense, betitex results will have direct socio-economic impact in the textile industry.  
  
the textile and clothing industry plays an important role to the european economy and well-being. according to euratex (the european apparel and textile confederation): in 2015, the overall size of the textile & clothing industry in the eu-28 represented a turnover of 169 billion â¬ and investments of around 4 billion â¬, employing over 1.7 million workers. eu external trade was more dynamic than the previous year with 45 billion â¬ of t&c products exported and 109 billion â¬ imported from third marketsâ.  
  
after china, the eu is the worldâ´s second largest exporter of textile products with 31% including intra- eu trade.  
  
according to the european commission âthe eu textile and clothing sector is a smes based industrial sector as companies of less of 50 employees account for more than 90% of the workforce and produce almost 60% of the value added.â  
  
the largest activity within the textile and clothing sector (at nace division level) is the manufacturing of textiles which accounted for a little under one half (49 %) of sectorial turnover in 2013.  
  
the textile and clothing sector in europe has been subject to a series of radical transformations over the last years, due to a combination of technological changes, evolution of production costs, the emergence of important international competitors and the elimination of import quotas after 2004. in response to competitive challenges, the textile and clothing industry in europe has improved its competitiveness by ceasing mass production and simple fashion products and concentrating instead on sustainable products with higher added value.  
  
the textile and clothing industry is highly interconnected, which means that changes in the trade and production of textiles and clothing can have significant positive or negative impacts on national economies, and/or the growth or subsidence of the industry. in general, the textile and clothing industry can be considered as a catalyst for economic growth in developing countries, due to its suitability for people with limited skills and education. despite the health risks and low income, it is often the most economically viable source of employment in areas where other occupations are either not available or do not provide sufficient income.  
  
general betitex project benefits for smes and smesâ trade associations on the textile sector at european and/or international level can be summarized as follows:  
  
- increasing their productivity, opening new market and extending their product range by manufacturing an innovative product.  
  
- bringing to the market cost-efficient and long lasting products responding to the consumer need.  
  
- bringing to the market ready-to-use and odourless ticks and bedbugs protecting fabrics avoiding the application of repellents sprays on clothes.  
  
by strengthening the role of high technology in the textile industry, smes would be re-launched in the european and international market; foreign direct investment will be attract to reinvest in an area of high quality and with high technological potential; scientific research will be incentivized; european market will tend more and more to products that comply with european environmental policies encouraging foreign competitors to conform to the same rules in order to be competitive; as well as it would be an advantage for the labour market and local economies.  
  
given the high potential market opportunities of betitex outcomes, the results of the project will improve the competitiveness of the sme participants by providing them with a valuable know-how.   
  
in parallel, by stimulating traditional textiles companies to develop innovative and sustainable products with a high and important social protective function, the project will introduce to the market an innovative product with health benefits and low environmental impact. moreover, thanks to the environmental friendly biocides used (accepted by the regulation (eu) no 528/2012), the smes will gain a high added value in a european (but also international) market that becomes more and more environmental sensitive, in sectors where there is a high interest and every time more needs of this protective function due to the high presence of bugs. all these factors will have an impact also at economic level (growth, production, labour market).  
  
there is a need of offering to the market innovative and technical fabrics to cover some lacks and then, being capable to differenciate them from the competence in order to contribute to a growth economy.   
  
betitex project has not only been focused on final fabric finishing, but also on the extrusion process in order to get a wide range of application possibilities and so, offering solutions for more diverse smes (not only finishing sector but also extrusion and spinning sectors). the potential growth of these smes may have an automatic impact on the labour demand and so on employment rate in the nearly future.  
  
in line with the europe 2020 strategy and the related european employment strategy, betitex project seeks to create more and better jobs on textile sector throughout the eu.  
  
impact - societal implications  
  
as it has been shown, ticks and bedbugs are in resurgence and this directly affects human health.  
  
especially the presence of ticks is of higher concern as it transmits infectious pathogens.   
  
approximately 820 species of ticks have been identified worldwide. of these, 100 are capable of transmitting pathogens such as bacteria, viruses and protozoa, and some tick even poisons, to humans. in europe it is almost always ixodes ricinus (http://www.lymeneteurope.org/info/ticks).  
   
main common infections are: crimean-congo haemorrhagic fever, lyme disease, relapsing fever (borreliosis), rickettsial diseases (spotted fever and q fever), tick-borne encephalitis and tularaemia.  
  
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cchf is endemic in africa, the balkans, the middle east and asian countries south of the 50th parallel north â the geographical limit of the principal tick vector.   
  
the hosts of the cchf virus include a wide range of wild and domestic animals such as cattle, sheep and goats. many birds are resistant to infection, but ostriches are susceptible and may show a high prevalence of infection in endemic areas, where they have been at the origin of human cases.   
  
animals become infected by the bite of infected ticks and the virus remains in their bloodstream for about one week after infection, allowing the tick-animal-tick cycle to continue when another tick bites.   
  
the cchf virus is transmitted to people either by tick bites or through contact with infected animal blood or tissues during and immediately after slaughter. the majority of cases have occurred in people involved in the livestock industry, such as agricultural workers, slaughterhouse workers and veterinarians.  
  
although an inactivated, mouse brain-derived vaccine against cchf has been developed and used on a small scale in eastern europe, there is currently no safe and effective vaccine widely available for human use.  
  
in the absence of a vaccine, the only way to reduce infection in people is by raising awareness of the risk factors and educating people about the measures they can take to reduce exposure to the virus.  
  
according to the european center for disease prevention and control, (http://ecdc.europa.eu/en/healthtopics/vectors/infographics/pages/infographic-tick-borne-diseases-in-europe.aspx) lyme disease is the most prevalent tick-borne-disease in europe. the main european vector is ixodes ricinus.  
  
an article from lymenet europe (http://www.lymeneteurope.org/info/) states that lyme disease is predominant on the northern hemisphere in temperate climates, which goes together with the spread of ticks. on a world map it is a band going over the unites states, europe, and across central asia all the way to japan.  
  
in order to reduce the risk of tick-to-human transmission, amongst all the proposed measures by the who, there are some in which betitex can have direct impact: wear protective clothing (long sleeves, long trousers) or to use approved repellent on the skin and clothing.  
  
concerning the reduction of risk in animal-to-human transmission, betitex can have impact on: wear gloves and other protective clothing while handling animals or their tissues in endemic areas, notably during slaughtering, butchering and culling procedures in slaughterhouses or at home.  
  
betitex prototypes can be turned into marketable products which can help to avoid ticks and bedbug bites on humans.  
  
dissemination and exploitation  
  
betitex had a work package exclusively dedicated to dissemination. the objective was to elaborate and implement a dissemination plan agreed by all members of the consortium, to attract the interest of the public, investors, research sector, smes and associations of smes through the publication of articles and advertisements in dedicated technical press, to elaborate and exploitation plan agreed by all members of the consortium and to ensure that the achievement of the project results are made available to the targeted potential clients and (or) market segments and to provide key information for the feasibility demonstration of smes solutions for getting protective textiles for ticks and bedbugs attack mainly focused on two sectors: protective garments for outdoor activities and home textiles.  
  
main dissemination activities include:  
  
- elaboration and updating of a project website: www.betitex.eu   
  
- creation of a project video: https://vimeo.com/181630794  
  
- distribution of press releases to textile and general media in the project partnersâ countries.  
  
- distribution of project leaflets and exhibition of the project poster or roll-up in several international events related to the textile sector, such as: techtextil frankfurt, heimtextil, medica, milano unica, itma, ispo, etc.  
  
- project presentations in scientific or congresses: betitex partners have done 4 presentations at 3 international events: texchemâ14 and ifatccâ16 (pardubice, czech republic) and the conference of the european textile technology platform: european textiles: going digital, going high-tech on octoberâ16 (brussels, belgium).  
  
besides, other activitie ...

# BETITEX

Project Acronym: BETITEX

programme & topic: FP7-SME SME-2013-2

Most frequent returning words in objectives:

* ('textile', 50)
* ('textiles', 34)
* ('biocide', 31)
* ('bedbugs', 27)
* ('project', 26)
* ('ticks', 24)
* ('betitex', 22)
* ('clothing', 21)
* ('figure', 20)
* ('biocides', 18)
* ('application', 18)
* ('market', 18)
* ('materials', 15)
* ('smes', 14)
* ('products', 14)
* ('europe', 14)
* ('protective', 13)
* ('sol-gel', 13)
* ('fabrics', 13)
* ('protection', 12)
* ('order', 12)
* ('sector', 11)
* ('effect', 11)
* ('impact', 11)

executive summary:  
betitex is a research and development project, cofounded by the european union's seventh framework programme (fp7/2007-2013) under grant agreement nâº 606517, starting on november 2013 and lasting 36 months.  
  
its aim is to obtain textile materials capable of providing protection against ticks and bedbugs, arthropods of medical and veterinary importance all over the world, in order to solve the current lack of protective solutions.   
  
it is coordinated by gremi tãxtil de terrassa, a non-profit catalan organization which joins more than 120 companies in the textile sector. in betitex, gremi leads a consortium of 10 partners: 3 textile associations (ateval from spain, clutex from czech republic and texclubtec from italy); 3 technological centers (inotex from czech republic and leitat and tecnalia both from spain; 4 smes (gemâinnov from france, nilka from turkey and silk&progress from czech republic and liasa from spain).  
  
the research and development activities carried out are focused on:  
  
1. study and selection of the biocides and the textile materials where to be applied.  
  
2. study and define the incorporation of the biocides to the textile materials. the selected technologies are: microencapsulation and application of microcapsules by finishing processes, during the extrusion and sol-gel technology.  
  
3. develop and validate test methods of biological effectiveness  
  
4. application of the biocides to textile materials   
  
5. determination of the durability of the biocide effect  
  
6. industrialization of the optimal solution  
  
these tasks have been structured in a work plan consisting on five r&d work packages and one demonstration work package.  
  
in order to assure the communication of the project and its results to the general public, scientific community and other stakeholders and the correct management of the project, two transversal work packages have been carried out during the whole project: dissemination and management.  
  
the final betitex result is a prototype of a textile material: efficient, environmentally friendly and with a slow release of biocide. this prototype will be the base for new final products such as mattress covers or other home textiles protecting against bedbugs and also garments for outdoor activities protecting against ticks.  
  
project context and objectives:  
other arthropods, increased restrictions on the use of pesticides, climate change and other anthropogenic factors (e.g. changes in agricultural practices).  
  
vectors are living beings which carry and transmit infectious pathogens to other living organisms.  
  
according to the who - world health organization, vector-borne diseases account for over 17% of all infectious diseases, and cause every year more than 1 million deaths.  
  
some of the resurging vectors are mosquitoes, lice, ticks and fleas.  
  
figure 1 shows the presence of ixodes ricinus (common tick) in europe. an increase is observed from 2012 to 2016, especially in the countries of central europe.  
  
figure 1: presence of ixodes ricinus in europe  
source: european center for disease prevention and control (ecdp)  
  
ticks are small arachnids that feed on blood. they are found mainly in habitats with vegetation, maintaining high humidity, such as woodlands.   
  
they are involved in the transmission of a variety of pathogens of major medical and veterinary importance. two of the major diseases transmitted by the common tick are:  
  
- lyme borrellosis (lyme disease): is the main tick-borne disease in europe. it can affect the nervous system. 10% of infected people may develop disorders in the central nervous system.  
  
- tick-borne encephalitis (tbe): is a viral infection that causes brain inflammation in 25% of infected people. russia and europe report between 10,000 and 12,000 cases of infections in humans each year.  
  
other arthropods in resurgence are bedbugs, insect parasites of the cimicidae family that feed exclusively on blood. the common bedbug is the cimex lectularius.  
the increased presence of bedbugs is attributed to increased international travel, climate change, mismanagement of insecticides and the development of insect resistance to insecticides (mainly pyrethroids).  
  
bedbugs are suspected of transmitting infectious agents. there is international concern about their vectorial capacity (about 40-45 pathogens have been detected in wild bedbugs and/or lab bedbugs), some as important as chagas disease or hepatitis b. however, no data exists demonstrating their efficient transmission under natural conditions.  
  
bedbugs can reduce the quality of life, causing anxiety, discomfort, skin disorders, insomnia, anaemia (when many) and may even cause anaphylaxis. they have a great negative impact on tourism at world level.  
  
the habitats of the bedbugs are especially sofas, mattresses and other furniture.   
  
in spain, the most demanded bedbug pest control services are distributed as shown in figure 2.  
  
an example of the resurgence of bedbugs in the united states is shown in figure 3. since 2000 until today, the presence of bedbugs has increased up to 70%.  
  
figure 2: distribution of services required for bedbugs pest control   
source: national association of pest control (anecpla)  
  
figure 3: evolution of the presence of bedbugs in the united states  
source: hilton head exterminators   
  
bedbugs and ticks, despite being present in different habitats, have similar behavior and are affected by the same type of biocide.  
  
nowadays the most used method to fight them is using a repellent-spray. these sprays contain the biocides responsible of providing protection to the user. there are not too many authorized repellents by the regulation (eu) no 528/2012. many known active substances are not accepted in the european market due to their toxicity and/or their environmental impact.   
  
to solve the current lack of protection against bites of these two types of arthropods, the betitex project was conceived.  
  
main betitex objectives are:  
  
â¢ to develop functional textiles with protection against ticks and bedbugs, mainly for outdoor garments and home textiles.  
  
â¢ to develop and research on environmentally friendly biocides offering protection against ticks and bedbugs and accepted by the regulation (eu) no 528/2012.  
  
â¢ to develop innovative finishing technologies (sol-gel, microencapsulation and extrusion) in order to control the repellent effect and so contributing to a longer lifespan (control-release of the biocide).  
  
â¢ to obtain high durability of the finishing (maintaining the repellence property at least up to 50 washings) by biocide control release (long-lasting biocide treated textiles)  
  
â¢ to reduce the use of repellent sprays that are used nowadays (spreading them on the human body).  
  
â¢ to promote the betitex results by the sme-associations involved in the project to their smes associated companies, in the textile sector.  
  
â¢ to offer solutions to the smes and improve their competitiveness by getting protective textiles against ticks and bedbugs in the field of outdoor garments and home textiles.  
  
project results:  
betitex project research activities have been structured in five r&d work packages and one demonstration work package. figure 4 shows the project workplan.  
  
figure 4. betitex workplan  
  
wp1. study and selection of the materials  
  
1. study and selection of biocides  
  
there are a wide variety of biocide products all over the world. environmental disturbances and public health risks derived from abuse of pesticides are constant alerts that demand innovative researches. in this sense, this task had the aim to select the biocides between accepted ones, by regulation (eu) no 528/2012.  
  
the selection has been divided in two main tasks: an initial selection of biocides in which a bibliographic review of selected chemicals known to have repellent and/or insecticidal effects on ticks /bedbugs all over the world has been done. for the final selection, the bibliographically pre-selected biocides (with repellent effect (pt19) and insecticidal effect (pt18)) have been evaluated against bedbugs and ticks in the laboratory, though in vitro feed screening tests.  
  
three repellents and three insecticides were selected.  
  
2. study and selection of textile raw materials  
  
in this task, the textile materials to be used as raw materials in the following work packages have been selected.  
  
the selection process began with a study on the presence, habitat, hazards, etc. of bedbugs and ticks.   
  
as a result of this study the major application sectors have been selected: clothing for outdoor activities and personal protective clothing (protection against ticks) and home textiles (protection against bedbugs).   
  
from these sectors, the most commonly used textile materials have been studied, in terms of raw materials and structures, with a final selection of four substrates.  
  
wp2. study and definition of the biocides incorporation on textiles  
  
in this wp, different methodologies for including the previously selected biocides into the selected fabrics have been studied.  
  
these technologies include:  
  
1. embedding technologies of the biocide: sol-gel coating and micro and nanoencapsulation of the biocide.  
  
the sol-gel technology consists of a series of hydrolysis and condensation reactions, whereby one solution (sol-gel) containing the biocide inside is obtained. it is a method well known to provide new functionalities to materials.  
  
the main advantage of insecticide/repellent textiles by sol-gel coatings is the control over the amount of insecticide/repellent into the silica coating and the excellent adhesion of sol-gel coating to the textile fibres due to the nanoparticulate size of the sol particles.  
  
the micro/nano encapsulation (depending on the size of the capsule) is a process by which the active ingredient (in this case the biocide) is wrapped with a protective layer (shell) that allows a controlled release.   
  
the need for biocides encapsulation is mainly based on their toxicity for both human or animals and the environment. although isolation of the insecticide is required regarding health issues, proper and controlled release in the target has to be performed to achieve the active effect. thereby, the main challenge for selected polymer matrix or shell is the matching of compromise between a good protection of biocide and an appropriate liberation of product at the correct dosage. additionally, controlled release of biocide may result in a reduction in resistance of bugs or ticks, providing an added value.  
  
the concern of minimizing the contact between biocides and human skin or environment has been growing in the last years and different encapsulation approaches have been studied and evaluated.  
  
2. application of the embedded biocide onto textile materials. two different technologies have been studied: finishing technologies and extrusion.  
  
the finishing technologies selected are: padding, coating and exhaustion. the extrusion process consists on the incorporation of the micro or nanoencapsulated biocide in a polypropylene yarn during its extrusion.  
  
the usual problem in the application of biocides on the fabrics is low durability of their biological efficacy after washing. for that reason, the efforts have been focused on finding new methodologies characterized by a slow release of the biocide from the textile and a high resistance to washing.   
  
as final result, a definition and description of the potential processes to be followed according to the biocides and fabrics selected has been obtained.  
  
wp3. development and validation of biological effectiveness test methods  
  
the goal of this workpackage is to study and define the methodology for testing fabrics with effect against ticks and bedbugs.  
  
first task of the wp was the laboratory in-vitro cultures (ixodidae and cimicidae). second task was the development of the methodology to assess antitick and antibedbug properties of the biocide treated textile materials.  
  
cimex lectularius l. was selected as the cimicid target of the betitex project for its worldwide distribution and its high signification as manâ´s parasite because of its strong semisynanthropic habits. c. lectularius is a hemimetabolous insect that requires vertebrate blood in all five nymphal instars as well as in the adult stage. original hosts of bed-bugs are bats, but they have evolved switching to other vertebrate species, including man.  
  
figure 5. cimex lectularius l.  
  
ixodes ricinus was selected as it is the most widespread and abundant ixodid tick in western europe and frequently bites humans. it is an important vector of zoonotic diseases, including lyme disease, tick borne encephalitis, ehrlichiosis and babesiosis (bonnet et al, 2007).  
  
figure 6. ixodes ricinus  
  
wp4. application of biocides and characterization  
  
this wp consists on the application of the selected biocide onto the selected textile materials by using the selected methodologies, at laboratory scale.  
  
the wp is divided in three main tasks:  
  
1. sol-gel formulation and application: development of a sol-gel formulation containing a repellent and/or insecticide: studying type of precursor, ph, water/alkoxide ratio, type of catalyst, solvent, time and temperature and amount of insecticide/repellent.  
  
the sol-gel formulation has been applied onto the textile material by padding.  
  
figure 7. sol-gel process  
  
1. microcapsules development and application on textiles  
  
the micro/nanoencapsulation process avoids the degradation of the core, masks odours, protects the core during the processing and allows controlled-release of the active substance.  
  
the three types of encapsulation used are: sol-gel nanocapsules, in-situ polymerization and interfacial polymerization.  
  
figure 8. microcapsules on cotton fibers  
the obtained micro and/or nanocapsules have been incorporated onto textiles by: padding, exhaustion and coating, and within a polypropylene yarn.  
  
once introducing microcapsules in a formulation, different parameters have to be studied such as the dispersion level, the stability of the dispersion, the concentration of microcapsules and the concentration of the binder.  
  
the concentration of the microcapsules applied on the fabric has also to be controlled in order to employ the minimum quantity of microcapsules necessary to obtain a good effectiveness and a good washing fastness of the effect.  
  
the padding process consists of introducing the solution containing the insecticide inside the padding machine and the fabric is squeezed between the machine rolls after being impregnated in the solution. then the textiles are dried and cured in a stenter.  
  
the coating process can be done by foaming or not the solution. in foam coating the application on the fabric is done by a knife coating machine. after application on the fabric, the textile is dried and cured to fix the finishing layer on its surface.  
  
the exhaustion process consists in immersing the fabric inside a solution containing the insecticide during a specific period of time and at a specific temperature profile, until exhausting the bath. the fabric is also submitted to agitation to enhance its impregnation into the bath. then, the textiles are finally dried.  
  
the process of applying the micro/nanocapsules within the polypropylene yarn is shown at figure 9.  
  
 figure 9. incorporation of micro/nanocapsules containing biocide on a polypropylene yarn  
  
figure 10. diagram of the application processes which have been carried out in wp4  
  
3. characterization  
  
the obtained fabrics and yarns have been characterized according to the tests shown in figure 11, in order to determine the biocide content on the micro/nanocapsules, once they have been applied onto the textile materials, their structure and also the main properties of the fabrics to confirm they maintain their initial properties (before being treated).  
  
figure 11. characterization tests  
  
wp5. determination of durability and optimization  
  
the objective of this wp is to determine the effectiveness of biocide by means of repellency and mortality tests (according to the biocide used) conducted adapting methodologies to betitex project (previously defined in wp3).  
  
effectiveness has been determined without washing and then with 1, 5, 25 and 51 washes, as this is one of the weaknesses of the technologies used.  
  
moreover, a complete characterization of the fabrics according final fabric application has been done in order to define if the optimum fabric is capable of providing with biocide effect without reducing common and usual characteristics.  
  
the different research lines studied in wp4 have been further evaluated aiming to determine the most feasible options to be transferred to industrial scale in wp6.  
  
figure 12. mortality tests  
  
figure 13. repellence tests  
  
on the other hand, due to the different end uses of the products developed, it is necessary to determine the complementarity of the biocide application processes with other necessary finishes depending on application.  
  
functional clothing is relatively new and a growing segment of the textile clothing group. the field of functional clothing is wide and diverse with each functionality having its own specification, material requirements, consequent technologies and processes. all clothing is known to perform multiple functions from aesthetic to basic protection from the external environment elements and respect of users comfort.  
  
functional clothing can therefore be defined as a generic term related to both - clothing or assemblies that are specifically engineered to deliver various predefined performances or functionality to end user who goes over its normal function. standard classification used for technical textiles divides the textiles to the three basic groups: protective, medical, sports/outdoor textiles. the protective â functional presents the largest segment of functional clothing (ppe) â one of highlighted. more and more the (multi)functional textiles penetrate in o the b2b (barrier) textiles for technical uses as well.  
  
the textile industry is constantly striving for innovative production techniques to improve product quality. besides the traditional function by dressing people, textiles now provide wear comfort and protection in dangerous environments. textile finishing chemicals are used to convert a textile material into a technical textile with functional properties. in the textile industry, finishing is usually carried out in the final stage of textile processing, as a result of which the textiles gain several functional characteristics. novel finishes providing high value addition to textile fabrics are greatly appreciated by a more demanding consumer market. the functional finishes can also be applied to apparel fabrics, household textiles and technical textiles to increase their attractiveness to the consumer and to stimulate growth at the niche markets.  
  
there are different types of functional finishes and the right type of finish should be decided depending on the fibre type of the textile substrate and the desired end use. the additional costs of the multifunctional textiles must be compensated by durability of functional effects. more and more the (multi)functional finishing processes work together with the maintenance service processing.  
  
the multi-functionalization has been tested with hydrophobic finish and antibacterial finish.  
  
finishes that repel water are important in all categories of the textile market. hydrophobic finishes give additional properties on fabrics to realize higher value textile products. repellence properties also enable easier cleaning of fabrics.   
  
the growth of microorganisms on textiles leads to the generation of unpleasant odour, discoloration of the fabric and reduction in the fabric strength and other useful properties. for these reasons, it is highly desirable that the growth of microorganisms on textiles is minimised during their storage and use.   
  
after the application of the multifunctional treatments, effectiveness tests have been carried out in order to determine which is the final effect.  
  
wp6. industrialization of the optimal solution: microencapsulation, finishing and extrusion  
  
the last stage of the project involves the industrialization of the optimal solution obtained in the previous wp, at the premises of the participating smes in the project.  
  
various microcapsulesâ types have been developed and characterized (particle size and spherical form). the capsules prepared have been compared to the capsules obtained at laboratory scale. the presence of the biocide has been determined as well after the microencapsulation process.  
  
from one side, these microcapsules have been used for the production of a biocide yarn and, from the other side, they have been applied onto textiles by the mentioned finishing processes.  
  
figure 14. industrialization scheme  
  
final results of the betitex can be summarized as follows:  
  
- functional textile material with protection against ticks and bedbugs for ppe â personal protective equipment and home textiles applications.  
  
- use of environmentally friendly biocides offering protection against ticks and bedbugs which are accepted by the regulation (eu) no 528/2012 of the european parliament and of the council of 22 may 2012 concerning the making available on the market and use of biocidal products.  
  
- use of innovative finishing technologies (sol-gel, microencapsulation and extrusion) in order to control the repellent effect and so contributing to a longer lifespan (control-release of the biocide).  
  
- obtaining high durability of the biocide effect (maintaining the biocide property at least up to 50 washings) by biocide control release (long-lasting biocide treated textiles).  
  
in general terms, and according to the market research on available similar products on the market, results of effectiveness achieved are considered as satisfactory.  
  
potential impact:  
socio-economic impact  
  
betitex has been carried out by a consortium mainly set up of textile organizations: textile trade associations, technological centers and smes.  
  
in that sense, betitex results will have direct socio-economic impact in the textile industry.  
  
the textile and clothing industry plays an important role to the european economy and well-being. according to euratex (the european apparel and textile confederation): in 2015, the overall size of the textile & clothing industry in the eu-28 represented a turnover of 169 billion â¬ and investments of around 4 billion â¬, employing over 1.7 million workers. eu external trade was more dynamic than the previous year with 45 billion â¬ of t&c products exported and 109 billion â¬ imported from third marketsâ.  
  
after china, the eu is the worldâ´s second largest exporter of textile products with 31% including intra- eu trade.  
  
according to the european commission âthe eu textile and clothing sector is a smes based industrial sector as companies of less of 50 employees account for more than 90% of the workforce and produce almost 60% of the value added.â  
  
the largest activity within the textile and clothing sector (at nace division level) is the manufacturing of textiles which accounted for a little under one half (49 %) of sectorial turnover in 2013.  
  
the textile and clothing sector in europe has been subject to a series of radical transformations over the last years, due to a combination of technological changes, evolution of production costs, the emergence of important international competitors and the elimination of import quotas after 2004. in response to competitive challenges, the textile and clothing industry in europe has improved its competitiveness by ceasing mass production and simple fashion products and concentrating instead on sustainable products with higher added value.  
  
the textile and clothing industry is highly interconnected, which means that changes in the trade and production of textiles and clothing can have significant positive or negative impacts on national economies, and/or the growth or subsidence of the industry. in general, the textile and clothing industry can be considered as a catalyst for economic growth in developing countries, due to its suitability for people with limited skills and education. despite the health risks and low income, it is often the most economically viable source of employment in areas where other occupations are either not available or do not provide sufficient income.  
  
general betitex project benefits for smes and smesâ trade associations on the textile sector at european and/or international level can be summarized as follows:  
  
- increasing their productivity, opening new market and extending their product range by manufacturing an innovative product.  
  
- bringing to the market cost-efficient and long lasting products responding to the consumer need.  
  
- bringing to the market ready-to-use and odourless ticks and bedbugs protecting fabrics avoiding the application of repellents sprays on clothes.  
  
by strengthening the role of high technology in the textile industry, smes would be re-launched in the european and international market; foreign direct investment will be attract to reinvest in an area of high quality and with high technological potential; scientific research will be incentivized; european market will tend more and more to products that comply with european environmental policies encouraging foreign competitors to conform to the same rules in order to be competitive; as well as it would be an advantage for the labour market and local economies.  
  
given the high potential market opportunities of betitex outcomes, the results of the project will improve the competitiveness of the sme participants by providing them with a valuable know-how.   
  
in parallel, by stimulating traditional textiles companies to develop innovative and sustainable products with a high and important social protective function, the project will introduce to the market an innovative product with health benefits and low environmental impact. moreover, thanks to the environmental friendly biocides used (accepted by the regulation (eu) no 528/2012), the smes will gain a high added value in a european (but also international) market that becomes more and more environmental sensitive, in sectors where there is a high interest and every time more needs of this protective function due to the high presence of bugs. all these factors will have an impact also at economic level (growth, production, labour market).  
  
there is a need of offering to the market innovative and technical fabrics to cover some lacks and then, being capable to differenciate them from the competence in order to contribute to a growth economy.   
  
betitex project has not only been focused on final fabric finishing, but also on the extrusion process in order to get a wide range of application possibilities and so, offering solutions for more diverse smes (not only finishing sector but also extrusion and spinning sectors). the potential growth of these smes may have an automatic impact on the labour demand and so on employment rate in the nearly future.  
  
in line with the europe 2020 strategy and the related european employment strategy, betitex project seeks to create more and better jobs on textile sector throughout the eu.  
  
impact - societal implications  
  
as it has been shown, ticks and bedbugs are in resurgence and this directly affects human health.  
  
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according to the european center for disease prevention and control, (http://ecdc.europa.eu/en/healthtopics/vectors/infographics/pages/infographic-tick-borne-diseases-in-europe.aspx) lyme disease is the most prevalent tick-borne-disease in europe. the main european vector is ixodes ricinus.  
  
an article from lymenet europe (http://www.lymeneteurope.org/info/) states that lyme disease is predominant on the northern hemisphere in temperate climates, which goes together with the spread of ticks. on a world map it is a band going over the unites states, europe, and across central asia all the way to japan.  
  
in order to reduce the risk of tick-to-human transmission, amongst all the proposed measures by the who, there are some in which betitex can have direct impact: wear protective clothing (long sleeves, long trousers) or to use approved repellent on the skin and clothing.  
  
concerning the reduction of risk in animal-to-human transmission, betitex can have impact on: wear gloves and other protective clothing while handling animals or their tissues in endemic areas, notably during slaughtering, butchering and culling procedures in slaughterhouses or at home.  
  
betitex prototypes can be turned into marketable products which can help to avoid ticks and bedbug bites on humans.  
  
dissemination and exploitation  
  
betitex had a work package exclusively dedicated to dissemination. the objective was to elaborate and implement a dissemination plan agreed by all members of the consortium, to attract the interest of the public, investors, research sector, smes and associations of smes through the publication of articles and advertisements in dedicated technical press, to elaborate and exploitation plan agreed by all members of the consortium and to ensure that the achievement of the project results are made available to the targeted potential clients and (or) market segments and to provide key information for the feasibility demonstration of smes solutions for getting protective textiles for ticks and bedbugs attack mainly focused on two sectors: protective garments for outdoor activities and home textiles.  
  
main dissemination activities include:  
  
- elaboration and updating of a project website: www.betitex.eu   
  
- creation of a project video: https://vimeo.com/181630794  
  
- distribution of press releases to textile and general media in the project partnersâ countries.  
  
- distribution of project leaflets and exhibition of the project poster or roll-up in several international events related to the textile sector, such as: techtextil frankfurt, heimtextil, medica, milano unica, itma, ispo, etc.  
  
- project presentations in scientific or congresses: betitex partners have done 4 presentations at 3 international events: texchemâ14 and ifatccâ16 (pardubice, czech republic) and the conference of the european textile technology platform: european textiles: going digital, going high-tech on octoberâ16 (brussels, belgium).  
  
besides, other activitie ...

# BETITEX

Project Acronym: BETITEX

programme & topic: FP7-SME SME-2013-2

Most frequent returning words in objectives:

* ('textile', 50)
* ('textiles', 34)
* ('biocide', 31)
* ('bedbugs', 27)
* ('project', 26)
* ('ticks', 24)
* ('betitex', 22)
* ('clothing', 21)
* ('figure', 20)
* ('biocides', 18)
* ('application', 18)
* ('market', 18)
* ('materials', 15)
* ('smes', 14)
* ('products', 14)
* ('europe', 14)
* ('protective', 13)
* ('sol-gel', 13)
* ('fabrics', 13)
* ('protection', 12)
* ('order', 12)
* ('sector', 11)
* ('effect', 11)
* ('impact', 11)

executive summary:  
betitex is a research and development project, cofounded by the european union's seventh framework programme (fp7/2007-2013) under grant agreement nâº 606517, starting on november 2013 and lasting 36 months.  
  
its aim is to obtain textile materials capable of providing protection against ticks and bedbugs, arthropods of medical and veterinary importance all over the world, in order to solve the current lack of protective solutions.   
  
it is coordinated by gremi tãxtil de terrassa, a non-profit catalan organization which joins more than 120 companies in the textile sector. in betitex, gremi leads a consortium of 10 partners: 3 textile associations (ateval from spain, clutex from czech republic and texclubtec from italy); 3 technological centers (inotex from czech republic and leitat and tecnalia both from spain; 4 smes (gemâinnov from france, nilka from turkey and silk&progress from czech republic and liasa from spain).  
  
the research and development activities carried out are focused on:  
  
1. study and selection of the biocides and the textile materials where to be applied.  
  
2. study and define the incorporation of the biocides to the textile materials. the selected technologies are: microencapsulation and application of microcapsules by finishing processes, during the extrusion and sol-gel technology.  
  
3. develop and validate test methods of biological effectiveness  
  
4. application of the biocides to textile materials   
  
5. determination of the durability of the biocide effect  
  
6. industrialization of the optimal solution  
  
these tasks have been structured in a work plan consisting on five r&d work packages and one demonstration work package.  
  
in order to assure the communication of the project and its results to the general public, scientific community and other stakeholders and the correct management of the project, two transversal work packages have been carried out during the whole project: dissemination and management.  
  
the final betitex result is a prototype of a textile material: efficient, environmentally friendly and with a slow release of biocide. this prototype will be the base for new final products such as mattress covers or other home textiles protecting against bedbugs and also garments for outdoor activities protecting against ticks.  
  
project context and objectives:  
other arthropods, increased restrictions on the use of pesticides, climate change and other anthropogenic factors (e.g. changes in agricultural practices).  
  
vectors are living beings which carry and transmit infectious pathogens to other living organisms.  
  
according to the who - world health organization, vector-borne diseases account for over 17% of all infectious diseases, and cause every year more than 1 million deaths.  
  
some of the resurging vectors are mosquitoes, lice, ticks and fleas.  
  
figure 1 shows the presence of ixodes ricinus (common tick) in europe. an increase is observed from 2012 to 2016, especially in the countries of central europe.  
  
figure 1: presence of ixodes ricinus in europe  
source: european center for disease prevention and control (ecdp)  
  
ticks are small arachnids that feed on blood. they are found mainly in habitats with vegetation, maintaining high humidity, such as woodlands.   
  
they are involved in the transmission of a variety of pathogens of major medical and veterinary importance. two of the major diseases transmitted by the common tick are:  
  
- lyme borrellosis (lyme disease): is the main tick-borne disease in europe. it can affect the nervous system. 10% of infected people may develop disorders in the central nervous system.  
  
- tick-borne encephalitis (tbe): is a viral infection that causes brain inflammation in 25% of infected people. russia and europe report between 10,000 and 12,000 cases of infections in humans each year.  
  
other arthropods in resurgence are bedbugs, insect parasites of the cimicidae family that feed exclusively on blood. the common bedbug is the cimex lectularius.  
the increased presence of bedbugs is attributed to increased international travel, climate change, mismanagement of insecticides and the development of insect resistance to insecticides (mainly pyrethroids).  
  
bedbugs are suspected of transmitting infectious agents. there is international concern about their vectorial capacity (about 40-45 pathogens have been detected in wild bedbugs and/or lab bedbugs), some as important as chagas disease or hepatitis b. however, no data exists demonstrating their efficient transmission under natural conditions.  
  
bedbugs can reduce the quality of life, causing anxiety, discomfort, skin disorders, insomnia, anaemia (when many) and may even cause anaphylaxis. they have a great negative impact on tourism at world level.  
  
the habitats of the bedbugs are especially sofas, mattresses and other furniture.   
  
in spain, the most demanded bedbug pest control services are distributed as shown in figure 2.  
  
an example of the resurgence of bedbugs in the united states is shown in figure 3. since 2000 until today, the presence of bedbugs has increased up to 70%.  
  
figure 2: distribution of services required for bedbugs pest control   
source: national association of pest control (anecpla)  
  
figure 3: evolution of the presence of bedbugs in the united states  
source: hilton head exterminators   
  
bedbugs and ticks, despite being present in different habitats, have similar behavior and are affected by the same type of biocide.  
  
nowadays the most used method to fight them is using a repellent-spray. these sprays contain the biocides responsible of providing protection to the user. there are not too many authorized repellents by the regulation (eu) no 528/2012. many known active substances are not accepted in the european market due to their toxicity and/or their environmental impact.   
  
to solve the current lack of protection against bites of these two types of arthropods, the betitex project was conceived.  
  
main betitex objectives are:  
  
â¢ to develop functional textiles with protection against ticks and bedbugs, mainly for outdoor garments and home textiles.  
  
â¢ to develop and research on environmentally friendly biocides offering protection against ticks and bedbugs and accepted by the regulation (eu) no 528/2012.  
  
â¢ to develop innovative finishing technologies (sol-gel, microencapsulation and extrusion) in order to control the repellent effect and so contributing to a longer lifespan (control-release of the biocide).  
  
â¢ to obtain high durability of the finishing (maintaining the repellence property at least up to 50 washings) by biocide control release (long-lasting biocide treated textiles)  
  
â¢ to reduce the use of repellent sprays that are used nowadays (spreading them on the human body).  
  
â¢ to promote the betitex results by the sme-associations involved in the project to their smes associated companies, in the textile sector.  
  
â¢ to offer solutions to the smes and improve their competitiveness by getting protective textiles against ticks and bedbugs in the field of outdoor garments and home textiles.  
  
project results:  
betitex project research activities have been structured in five r&d work packages and one demonstration work package. figure 4 shows the project workplan.  
  
figure 4. betitex workplan  
  
wp1. study and selection of the materials  
  
1. study and selection of biocides  
  
there are a wide variety of biocide products all over the world. environmental disturbances and public health risks derived from abuse of pesticides are constant alerts that demand innovative researches. in this sense, this task had the aim to select the biocides between accepted ones, by regulation (eu) no 528/2012.  
  
the selection has been divided in two main tasks: an initial selection of biocides in which a bibliographic review of selected chemicals known to have repellent and/or insecticidal effects on ticks /bedbugs all over the world has been done. for the final selection, the bibliographically pre-selected biocides (with repellent effect (pt19) and insecticidal effect (pt18)) have been evaluated against bedbugs and ticks in the laboratory, though in vitro feed screening tests.  
  
three repellents and three insecticides were selected.  
  
2. study and selection of textile raw materials  
  
in this task, the textile materials to be used as raw materials in the following work packages have been selected.  
  
the selection process began with a study on the presence, habitat, hazards, etc. of bedbugs and ticks.   
  
as a result of this study the major application sectors have been selected: clothing for outdoor activities and personal protective clothing (protection against ticks) and home textiles (protection against bedbugs).   
  
from these sectors, the most commonly used textile materials have been studied, in terms of raw materials and structures, with a final selection of four substrates.  
  
wp2. study and definition of the biocides incorporation on textiles  
  
in this wp, different methodologies for including the previously selected biocides into the selected fabrics have been studied.  
  
these technologies include:  
  
1. embedding technologies of the biocide: sol-gel coating and micro and nanoencapsulation of the biocide.  
  
the sol-gel technology consists of a series of hydrolysis and condensation reactions, whereby one solution (sol-gel) containing the biocide inside is obtained. it is a method well known to provide new functionalities to materials.  
  
the main advantage of insecticide/repellent textiles by sol-gel coatings is the control over the amount of insecticide/repellent into the silica coating and the excellent adhesion of sol-gel coating to the textile fibres due to the nanoparticulate size of the sol particles.  
  
the micro/nano encapsulation (depending on the size of the capsule) is a process by which the active ingredient (in this case the biocide) is wrapped with a protective layer (shell) that allows a controlled release.   
  
the need for biocides encapsulation is mainly based on their toxicity for both human or animals and the environment. although isolation of the insecticide is required regarding health issues, proper and controlled release in the target has to be performed to achieve the active effect. thereby, the main challenge for selected polymer matrix or shell is the matching of compromise between a good protection of biocide and an appropriate liberation of product at the correct dosage. additionally, controlled release of biocide may result in a reduction in resistance of bugs or ticks, providing an added value.  
  
the concern of minimizing the contact between biocides and human skin or environment has been growing in the last years and different encapsulation approaches have been studied and evaluated.  
  
2. application of the embedded biocide onto textile materials. two different technologies have been studied: finishing technologies and extrusion.  
  
the finishing technologies selected are: padding, coating and exhaustion. the extrusion process consists on the incorporation of the micro or nanoencapsulated biocide in a polypropylene yarn during its extrusion.  
  
the usual problem in the application of biocides on the fabrics is low durability of their biological efficacy after washing. for that reason, the efforts have been focused on finding new methodologies characterized by a slow release of the biocide from the textile and a high resistance to washing.   
  
as final result, a definition and description of the potential processes to be followed according to the biocides and fabrics selected has been obtained.  
  
wp3. development and validation of biological effectiveness test methods  
  
the goal of this workpackage is to study and define the methodology for testing fabrics with effect against ticks and bedbugs.  
  
first task of the wp was the laboratory in-vitro cultures (ixodidae and cimicidae). second task was the development of the methodology to assess antitick and antibedbug properties of the biocide treated textile materials.  
  
cimex lectularius l. was selected as the cimicid target of the betitex project for its worldwide distribution and its high signification as manâ´s parasite because of its strong semisynanthropic habits. c. lectularius is a hemimetabolous insect that requires vertebrate blood in all five nymphal instars as well as in the adult stage. original hosts of bed-bugs are bats, but they have evolved switching to other vertebrate species, including man.  
  
figure 5. cimex lectularius l.  
  
ixodes ricinus was selected as it is the most widespread and abundant ixodid tick in western europe and frequently bites humans. it is an important vector of zoonotic diseases, including lyme disease, tick borne encephalitis, ehrlichiosis and babesiosis (bonnet et al, 2007).  
  
figure 6. ixodes ricinus  
  
wp4. application of biocides and characterization  
  
this wp consists on the application of the selected biocide onto the selected textile materials by using the selected methodologies, at laboratory scale.  
  
the wp is divided in three main tasks:  
  
1. sol-gel formulation and application: development of a sol-gel formulation containing a repellent and/or insecticide: studying type of precursor, ph, water/alkoxide ratio, type of catalyst, solvent, time and temperature and amount of insecticide/repellent.  
  
the sol-gel formulation has been applied onto the textile material by padding.  
  
figure 7. sol-gel process  
  
1. microcapsules development and application on textiles  
  
the micro/nanoencapsulation process avoids the degradation of the core, masks odours, protects the core during the processing and allows controlled-release of the active substance.  
  
the three types of encapsulation used are: sol-gel nanocapsules, in-situ polymerization and interfacial polymerization.  
  
figure 8. microcapsules on cotton fibers  
the obtained micro and/or nanocapsules have been incorporated onto textiles by: padding, exhaustion and coating, and within a polypropylene yarn.  
  
once introducing microcapsules in a formulation, different parameters have to be studied such as the dispersion level, the stability of the dispersion, the concentration of microcapsules and the concentration of the binder.  
  
the concentration of the microcapsules applied on the fabric has also to be controlled in order to employ the minimum quantity of microcapsules necessary to obtain a good effectiveness and a good washing fastness of the effect.  
  
the padding process consists of introducing the solution containing the insecticide inside the padding machine and the fabric is squeezed between the machine rolls after being impregnated in the solution. then the textiles are dried and cured in a stenter.  
  
the coating process can be done by foaming or not the solution. in foam coating the application on the fabric is done by a knife coating machine. after application on the fabric, the textile is dried and cured to fix the finishing layer on its surface.  
  
the exhaustion process consists in immersing the fabric inside a solution containing the insecticide during a specific period of time and at a specific temperature profile, until exhausting the bath. the fabric is also submitted to agitation to enhance its impregnation into the bath. then, the textiles are finally dried.  
  
the process of applying the micro/nanocapsules within the polypropylene yarn is shown at figure 9.  
  
 figure 9. incorporation of micro/nanocapsules containing biocide on a polypropylene yarn  
  
figure 10. diagram of the application processes which have been carried out in wp4  
  
3. characterization  
  
the obtained fabrics and yarns have been characterized according to the tests shown in figure 11, in order to determine the biocide content on the micro/nanocapsules, once they have been applied onto the textile materials, their structure and also the main properties of the fabrics to confirm they maintain their initial properties (before being treated).  
  
figure 11. characterization tests  
  
wp5. determination of durability and optimization  
  
the objective of this wp is to determine the effectiveness of biocide by means of repellency and mortality tests (according to the biocide used) conducted adapting methodologies to betitex project (previously defined in wp3).  
  
effectiveness has been determined without washing and then with 1, 5, 25 and 51 washes, as this is one of the weaknesses of the technologies used.  
  
moreover, a complete characterization of the fabrics according final fabric application has been done in order to define if the optimum fabric is capable of providing with biocide effect without reducing common and usual characteristics.  
  
the different research lines studied in wp4 have been further evaluated aiming to determine the most feasible options to be transferred to industrial scale in wp6.  
  
figure 12. mortality tests  
  
figure 13. repellence tests  
  
on the other hand, due to the different end uses of the products developed, it is necessary to determine the complementarity of the biocide application processes with other necessary finishes depending on application.  
  
functional clothing is relatively new and a growing segment of the textile clothing group. the field of functional clothing is wide and diverse with each functionality having its own specification, material requirements, consequent technologies and processes. all clothing is known to perform multiple functions from aesthetic to basic protection from the external environment elements and respect of users comfort.  
  
functional clothing can therefore be defined as a generic term related to both - clothing or assemblies that are specifically engineered to deliver various predefined performances or functionality to end user who goes over its normal function. standard classification used for technical textiles divides the textiles to the three basic groups: protective, medical, sports/outdoor textiles. the protective â functional presents the largest segment of functional clothing (ppe) â one of highlighted. more and more the (multi)functional textiles penetrate in o the b2b (barrier) textiles for technical uses as well.  
  
the textile industry is constantly striving for innovative production techniques to improve product quality. besides the traditional function by dressing people, textiles now provide wear comfort and protection in dangerous environments. textile finishing chemicals are used to convert a textile material into a technical textile with functional properties. in the textile industry, finishing is usually carried out in the final stage of textile processing, as a result of which the textiles gain several functional characteristics. novel finishes providing high value addition to textile fabrics are greatly appreciated by a more demanding consumer market. the functional finishes can also be applied to apparel fabrics, household textiles and technical textiles to increase their attractiveness to the consumer and to stimulate growth at the niche markets.  
  
there are different types of functional finishes and the right type of finish should be decided depending on the fibre type of the textile substrate and the desired end use. the additional costs of the multifunctional textiles must be compensated by durability of functional effects. more and more the (multi)functional finishing processes work together with the maintenance service processing.  
  
the multi-functionalization has been tested with hydrophobic finish and antibacterial finish.  
  
finishes that repel water are important in all categories of the textile market. hydrophobic finishes give additional properties on fabrics to realize higher value textile products. repellence properties also enable easier cleaning of fabrics.   
  
the growth of microorganisms on textiles leads to the generation of unpleasant odour, discoloration of the fabric and reduction in the fabric strength and other useful properties. for these reasons, it is highly desirable that the growth of microorganisms on textiles is minimised during their storage and use.   
  
after the application of the multifunctional treatments, effectiveness tests have been carried out in order to determine which is the final effect.  
  
wp6. industrialization of the optimal solution: microencapsulation, finishing and extrusion  
  
the last stage of the project involves the industrialization of the optimal solution obtained in the previous wp, at the premises of the participating smes in the project.  
  
various microcapsulesâ types have been developed and characterized (particle size and spherical form). the capsules prepared have been compared to the capsules obtained at laboratory scale. the presence of the biocide has been determined as well after the microencapsulation process.  
  
from one side, these microcapsules have been used for the production of a biocide yarn and, from the other side, they have been applied onto textiles by the mentioned finishing processes.  
  
figure 14. industrialization scheme  
  
final results of the betitex can be summarized as follows:  
  
- functional textile material with protection against ticks and bedbugs for ppe â personal protective equipment and home textiles applications.  
  
- use of environmentally friendly biocides offering protection against ticks and bedbugs which are accepted by the regulation (eu) no 528/2012 of the european parliament and of the council of 22 may 2012 concerning the making available on the market and use of biocidal products.  
  
- use of innovative finishing technologies (sol-gel, microencapsulation and extrusion) in order to control the repellent effect and so contributing to a longer lifespan (control-release of the biocide).  
  
- obtaining high durability of the biocide effect (maintaining the biocide property at least up to 50 washings) by biocide control release (long-lasting biocide treated textiles).  
  
in general terms, and according to the market research on available similar products on the market, results of effectiveness achieved are considered as satisfactory.  
  
potential impact:  
socio-economic impact  
  
betitex has been carried out by a consortium mainly set up of textile organizations: textile trade associations, technological centers and smes.  
  
in that sense, betitex results will have direct socio-economic impact in the textile industry.  
  
the textile and clothing industry plays an important role to the european economy and well-being. according to euratex (the european apparel and textile confederation): in 2015, the overall size of the textile & clothing industry in the eu-28 represented a turnover of 169 billion â¬ and investments of around 4 billion â¬, employing over 1.7 million workers. eu external trade was more dynamic than the previous year with 45 billion â¬ of t&c products exported and 109 billion â¬ imported from third marketsâ.  
  
after china, the eu is the worldâ´s second largest exporter of textile products with 31% including intra- eu trade.  
  
according to the european commission âthe eu textile and clothing sector is a smes based industrial sector as companies of less of 50 employees account for more than 90% of the workforce and produce almost 60% of the value added.â  
  
the largest activity within the textile and clothing sector (at nace division level) is the manufacturing of textiles which accounted for a little under one half (49 %) of sectorial turnover in 2013.  
  
the textile and clothing sector in europe has been subject to a series of radical transformations over the last years, due to a combination of technological changes, evolution of production costs, the emergence of important international competitors and the elimination of import quotas after 2004. in response to competitive challenges, the textile and clothing industry in europe has improved its competitiveness by ceasing mass production and simple fashion products and concentrating instead on sustainable products with higher added value.  
  
the textile and clothing industry is highly interconnected, which means that changes in the trade and production of textiles and clothing can have significant positive or negative impacts on national economies, and/or the growth or subsidence of the industry. in general, the textile and clothing industry can be considered as a catalyst for economic growth in developing countries, due to its suitability for people with limited skills and education. despite the health risks and low income, it is often the most economically viable source of employment in areas where other occupations are either not available or do not provide sufficient income.  
  
general betitex project benefits for smes and smesâ trade associations on the textile sector at european and/or international level can be summarized as follows:  
  
- increasing their productivity, opening new market and extending their product range by manufacturing an innovative product.  
  
- bringing to the market cost-efficient and long lasting products responding to the consumer need.  
  
- bringing to the market ready-to-use and odourless ticks and bedbugs protecting fabrics avoiding the application of repellents sprays on clothes.  
  
by strengthening the role of high technology in the textile industry, smes would be re-launched in the european and international market; foreign direct investment will be attract to reinvest in an area of high quality and with high technological potential; scientific research will be incentivized; european market will tend more and more to products that comply with european environmental policies encouraging foreign competitors to conform to the same rules in order to be competitive; as well as it would be an advantage for the labour market and local economies.  
  
given the high potential market opportunities of betitex outcomes, the results of the project will improve the competitiveness of the sme participants by providing them with a valuable know-how.   
  
in parallel, by stimulating traditional textiles companies to develop innovative and sustainable products with a high and important social protective function, the project will introduce to the market an innovative product with health benefits and low environmental impact. moreover, thanks to the environmental friendly biocides used (accepted by the regulation (eu) no 528/2012), the smes will gain a high added value in a european (but also international) market that becomes more and more environmental sensitive, in sectors where there is a high interest and every time more needs of this protective function due to the high presence of bugs. all these factors will have an impact also at economic level (growth, production, labour market).  
  
there is a need of offering to the market innovative and technical fabrics to cover some lacks and then, being capable to differenciate them from the competence in order to contribute to a growth economy.   
  
betitex project has not only been focused on final fabric finishing, but also on the extrusion process in order to get a wide range of application possibilities and so, offering solutions for more diverse smes (not only finishing sector but also extrusion and spinning sectors). the potential growth of these smes may have an automatic impact on the labour demand and so on employment rate in the nearly future.  
  
in line with the europe 2020 strategy and the related european employment strategy, betitex project seeks to create more and better jobs on textile sector throughout the eu.  
  
impact - societal implications  
  
as it has been shown, ticks and bedbugs are in resurgence and this directly affects human health.  
  
especially the presence of ticks is of higher concern as it transmits infectious pathogens.   
  
approximately 820 species of ticks have been identified worldwide. of these, 100 are capable of transmitting pathogens such as bacteria, viruses and protozoa, and some tick even poisons, to humans. in europe it is almost always ixodes ricinus (http://www.lymeneteurope.org/info/ticks).  
   
main common infections are: crimean-congo haemorrhagic fever, lyme disease, relapsing fever (borreliosis), rickettsial diseases (spotted fever and q fever), tick-borne encephalitis and tularaemia.  
  
according to the world health organization (who) (http://www.who.int/mediacentre/factsheets/fs208/en/) crimean-congo haemorrhagic fever (cchf) is a widespread disease caused by a tick-borne virus (nairovirus) of the bunyaviridae family. the cchf virus causes severe viral haemorrhagic fever outbreaks, with a case fatality rate of 10â40%.   
  
cchf is endemic in africa, the balkans, the middle east and asian countries south of the 50th parallel north â the geographical limit of the principal tick vector.   
  
the hosts of the cchf virus include a wide range of wild and domestic animals such as cattle, sheep and goats. many birds are resistant to infection, but ostriches are susceptible and may show a high prevalence of infection in endemic areas, where they have been at the origin of human cases.   
  
animals become infected by the bite of infected ticks and the virus remains in their bloodstream for about one week after infection, allowing the tick-animal-tick cycle to continue when another tick bites.   
  
the cchf virus is transmitted to people either by tick bites or through contact with infected animal blood or tissues during and immediately after slaughter. the majority of cases have occurred in people involved in the livestock industry, such as agricultural workers, slaughterhouse workers and veterinarians.  
  
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main dissemination activities include:  
  
- elaboration and updating of a project website: www.betitex.eu   
  
- creation of a project video: https://vimeo.com/181630794  
  
- distribution of press releases to textile and general media in the project partnersâ countries.  
  
- distribution of project leaflets and exhibition of the project poster or roll-up in several international events related to the textile sector, such as: techtextil frankfurt, heimtextil, medica, milano unica, itma, ispo, etc.  
  
- project presentations in scientific or congresses: betitex partners have done 4 presentations at 3 international events: texchemâ14 and ifatccâ16 (pardubice, czech republic) and the conference of the european textile technology platform: european textiles: going digital, going high-tech on octoberâ16 (brussels, belgium).  
  
besides, other activitie ...

# SESW

Project Acronym: SESW

programme & topic: FP7-IDEAS-ERC ERC-AG-SH6

Most frequent returning words in objectives:

* ('cotton', 7)
* ('fabrics', 7)
* ('england', 6)
* ('hand', 6)
* ('project', 6)
* ('wheels', 6)
* ('revolution', 5)
* ('textiles', 4)
* ('period', 4)
* ('arkwrightâ\x80\x99s', 4)
* ('machines', 3)
* ('textile', 3)
* ('principal', 3)
* ('women', 3)
* ('research', 3)
* ('findings', 3)
* ('range', 3)
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* ('fibres', 3)
* ('warps', 3)
* ('yarn', 2)
* ('wool', 2)

from the introduction of the spinning wheel to england during the later middle ages to its eclipse by powered spinning machines early in the nineteenth century, hand-spun yarn was vital to the success of the textile industries that dominated english manufacturing. indeed, hand spinning â of wool, flax and ultimately cotton â became the principal income-generating activity pursued by english women. for many of those women, it was also an essential means of furnishing their own families with textiles. spinning was, at one and the same time, the foundation of englandâs domination of international trade in textiles and a crucial means by which rural families supplied themselves with cloth.   
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Project Acronym: SESW

programme & topic: FP7-IDEAS-ERC ERC-AG-SH6

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* ('hand', 6)
* ('project', 6)
* ('wheels', 6)
* ('revolution', 5)
* ('textiles', 4)
* ('period', 4)
* ('arkwrightâ\x80\x99s', 4)
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# ALL4RESTgo2MARKET

Project Acronym: ALL4RESTgo2MARKET

programme & topic: FP7-SME SME-2013-3

Most frequent returning words in objectives:

* ('project', 32)
* ('rest', 27)
* ('mattress', 23)
* ('comfort', 22)
* ('textile', 22)
* ('fabrics', 21)
* ('properties', 18)
* ('developed', 17)
* ('partners', 17)
* ('all4restgo2market', 16)
* ('pyjamas', 16)
* ('materials', 16)
* ('pcms', 16)
* ('skin', 16)
* ('products', 14)
* ('order', 14)
* ('thermoregulation', 14)
* ('processes', 14)
* ('system', 14)
* ('dissemination', 14)
* ('sleep', 13)
* ('quality', 13)
* ('results', 13)
* ('manufacturing', 13)

executive summary:  
all4restgo2market project (addressed to demonstration action) was set as a direct continuation from the successful all4rest project. manufacturers of rest products are looking for comfort-improved rest systems in order to promote deeper, more recuperative sleep, to prevent nocturnal awakenings, to reduce time to sleep after an awakening and reducing sleep onset latency. the integrated solutions developed in all4rest were focused on achieving comfort improvement (physical and thermal) establishing quantitative and qualitative evaluation of comfort and/or sleep quality of each solution investigated within the project, but the developments didnât achieve a realistic commercialization stage. however, three main results of this previous project were taken into account by the researching team for moving to a pre-industrial stage:  
â¢ thermoregulation performance (mainly on mattresses) through finishing processes.  
â¢ use of biofibers (softer touch, better hand, intrinsic antibacterial properties) for knitted and weaved fabrics and garments -pyjamas and bedclothes-.  
â¢ a relationship can be established between experimental data of comfort measurements and âfeelingâ or ârest perceptionâ by end-users. in addition, polysomnographies/actigraphies are useful tools to evaluate rest quality, but it must be taken into account that some diseases causing serious sleep disorders cannot be avoided only with âtextile-basedâ solutions focused on rest systems (improved mattresses, clothing or bedlinen).  
  
following this context, then, some solutions were selected for validation/implementation within all4restgo2market in a pre-industrial stage: a) mattresses with thermoregulation performance, b) pyjamas manufactured with biofibre-based knitted fabrics that show soft touch and better hand than conventional co-based knitted fabrics, and c) bedclothes manufactured with biofibre yarns looking for enhanced soft touch and comfort over conventional materials or finished with pcms to improve thermoregulation performance of the end-user. these realistic solutions generated by all4rest previous project are able to be under regulation of actual textile standards without any need for modification.   
  
taking these considerations derived from the previous project, the smes involved in all4restgo2market were required to prove the viability of the new solutions in order to get a potential economic advantage. and also to explore new ways of using the acquired knowledge e.g. in other products of the rest system such as pyjamas, bedclothes... since in all4rest the most promising solutions developed (above mentioned) were carried out and manufactured successfully only at small scale and over a limited range of process parameters, it was still a strong need to produce enlarged solutions and to develop and validate all the up-to-scale manufacturing processes.  
  
experimental data (showing enhanced performance of tactile/thermal comfort) were required for validation on pre-industrial samples developed within all4restgo2market project. this validation was established again in order to provide useful data to develop and validate a business plan and associated commerciallization strategy.  
  
the rtd performers (aitex and ctb) have provided the validation/testing results to the smes (industrial partners ecus, rapife, aznar, finipur and devan) enabling these partners to carrying out activities to validate/implement and to exploit them, according to the concept of âresearch for smeâ and call âfp7sme-2013 activity 2.3: demonstration actionâ. the achievement of the goals above mentioned were supported by technomar establishing and carrying out a strong and coherent bussiness and commerciallization plan, in order to ensure successful further exploitation roads to industrial partners for their innovative all4restgo2market end-products and processes.   
  
project context and objectives:  
the most promising results of the all4rest project shown that different biofibers can be integrated in manufacturing processes to develop textile-based products like mattress ticking, knitted fabrics for pyjamas or plain fabrics for bedclothes. the use of these biofibres results into enhanced soft touch, handle and skin benefits compared to conventional fibers (cotton or polyester). in addition, new microencapsulated finishing systems with thermoregulating materials (like phase change materials, pcms) were developed with increased linking force between pcms and fibers; as a result washing and rubbing fastness of finished fabrics were enhanced and control of warm/cold feeling on mattress ticking was achieved. specific techniques of comfort evaluation were implemented getting a well-balanced evaluation methodology (from analytical and clinical tests to consumer test panels).  
  
in addition, requirements and weaknesses detected in common textile products used when sleeping were also the main background for the new project all4restgo2market. several studies have reported that sleep problems can be related to an uncomfortable mattress or sleep bedclothes resulting in suffering of short sleep cycles, low back discomfort, pain, or stiffness and shoulder pain. rest systems (composed by mattress, bedclothes, pyjamas and pillow) should be as comfortable as possible to users. and comfort concept depends on physical and thermal parameters. then, the development of ready-to-market solutions which allow the enhancement of usersâ´ sleep quality (increasing the tactile and thermal comfort of all elements forming the rest system) is considered a key issue for increasing sales in the rest systems industry. but, the real situation is that most of the commercially available textile elements of rest system are âconventionally-madeâ, with usual fibers and usual polymeric materials.  
  
â¢ mattresses. common textile materials used in the external layer of this element are usually a mixture of natural and synthetic fibers. combinations -varying compositions- of viscose/pes, pes/acrylic/pa, pes/viscose/pa, pes/pp, pes/co-fr, co/pes, pvc-coated/pes, bamboo/pes... are usually common depending the quality and price of the mattress. special fibers that can also be used in this field are hollow synthetic fibers or special synthetic fibers including in their core microspheres that absorb the exciding heat and that release it when the temperature decrease. some of these textile materials are finished with chemical products previous to be integrated in the manufacture of a mattress. finishing applications are mainly made by padding technique, in order to impregnate the fabric with waterdispersed chemical formulations to obtain some functionalities.  
  
â¢ bedclothes. main textile materials and fibers used for their manufacturing are 100% co, 100% pes, co/pes 80/20, co/pes 50/50 (for bed-linens, quilts and sheets) and wool, acrylics or hollow synthetic fibers in different compositions (e.g. for blankets). regarding bedclothes for people who are permanently staying in bed or spend most of the time in bed, the comfort properties are crucial, as the risk for bedsores is high. it is also extremely important that the bed textiles transmit possible moisture from the skin. disabilities also often lead to special functional requirements of clothing and textile products. persons with highly sensitive skin have to consider the skin contact or tactile properties and avoid clothing with hard seams. for wheelchair users and for persons lying prolonged time in bed, who have a relatively low heat production, the thermal comfort properties are important. the transmission of moisture (sweat) from the skin is also a frequent problem. also the mechanical durability of the materials in certain parts of the products can be a problem in many cases.  
  
â¢ pyjamas. they are the main textile end-product people use for sleeping. and in this type of textile products, comfort and safety are important issues. comfort in clothes like pyjamas or bodysuits for babies is critical from a thermal and tactile point of view. here, co fiber is the clear winner of the main commercially available textile materials used to knit these end-products. this fiber gives good breathability (transmission of water vapor) and doesnât irritate the skin but it hasnât intrinsc antibacterial properties; on the other hand, due to its high wettability, co fiber could increase skin irritation under sweating conditions (continuous high moisture level on the skin).  
  
having in mind this project context and previous experiences in all4rest project, all4restgo2market project was proposed to reach the following objectives, in order to ensure that the improved resting textile-based elements could be developed, exploited and put into market by the involved smes:  
â¢ developing and implementing tools (at least 3) to obtain consumer attitudes and awareness concerning improved solutions for rest systems. to evaluate âpricingâ consumer reaction versus new, improved and âadded-valueâ resting products (how much extra price do they want to pay). quantify consumer acceptance by segmentation of consumer groups at eu scale.  
â¢ validation of thermoregulating pcms systems in terms of concentration (in g/l) depending on the type of fabric to be finished (at least 2 types). analysis of thermoregulation effect in different types of mattress ticking (improvement of at least 15% than conventional). validation of manufacturing processes (finishing but also fabrication of thermoregulating mattresses).  
â¢ knitting/weaving tests of a variety of pre-selected biofibres and compositions (at least 3 compositions). validation of these manufacturing processes and subsequent processes (finishing/confection). determination of improved tactile comfort (at least 15% more than conventional) in pilot end-products and of benefits for the skin obtained for each biofibre composition.  
â¢ to evaluate a quantitative market potential at eu scale which can be targeted by the advantages of improved rest systems, and develop the most probale sales channels to reach those.  
â¢ development and execution of a strong dissemination plan for maximum impact within/outside the consortium, including countries of partners involved in all4restgo2market and having in mind a pan-european point of view (eu-27 and non eu-27 countries). to ensure successful exploitation roads to the smes involved for their innovative all4restgo2market endproducts and processes, but also to ensure adequate/correct ipr protection for all of them.  
â¢ to ensure that the objectives are met in the agreed time scales, the results are effectively exploited, and the deliverables and milestones are achieved. at the same time, to establish and operate management structures and processes, to ensure all4restgo2market milestones are achieved on time and that the budget is adequated managed, also to facilitate communication within the consortium and between the consortium and the ec; and to effectively manage financial and project reporting, technical risks and conflicts between the project partners.  
  
project results:  
the work performed since the beginning of the project and the main results achieved are described:  
  
in the wp1 a customer survey has been performed with telephone interviews and online surveys. also three focus group meetings have been performed in germany and in spain in order to get more information as preparation for the market study. some interviews were also organized with market experts to gain actual and non-public results from the sales product lines relevant for all4restgo2market, also to verify the results obtained, cosumer surveys and meetings with groups of experts from involved branches have been organized. the result of the wp was the analysis of consumer behaviour and structure of customer segments, the usp and the quantification of market segments and market potential.  
  
the market analysis showed that a significant share of 25 % (age 18-79) of people has sleep disturbances, in some cases caused by skin disorders. following a study from the german sleep society (dgsm, 2014) the economic damage in germany is estimated about 30 bn â¬ per year, which is about 1 % of gdp. it can be assumed that in other countries the situation may be comparable. in that sense, the increase of quality of rest would affect health and general conditions and even the economy would benefit.   
  
the wp2 started with the first analysis of the relationship between types of ticking for the mattress and the most suitable chemicals to be used for finishing. it was decided the application of the pcm finishing with other functionalities (flame retardancy, fr) on the textile destined to mattress ticking. first ticking composition was based in a functional fiber (celliant + polyester) loaded with microminerals that improves the blood circulation/oxygenation and enhances the rest performance. regarding the pcms, 2 types were delivered by devan (mikrathermic product range) both mixed with a fr. devan / ctb / finipur were running trials in order to set formulations and finishing parameters. fabric samples were tested by ctb/aitex in terms of flame retardant behaviour (fr finish mixed with the pcms), abrasion/pilling resistance and ir thermography. additive ecoflam p260 (non-halogen) allowed to pass en597 test. for pilling and abrasion resistance the mikrathermic tfr-mf micro-capsules came out as the best choice.   
  
then, the recipe for the pcm application -padding- on mattress ticking (ecus), used for the pre-industrial trial at finipur (as described in d2.1) included the follow chemicals -quantities not indicated due to confidentiality reasons-:  
- mikracat b (diluted in water, previously adjusted with citric acid-ph 4).  
- mikrathermic tfr-mf.  
- dev r-c.  
- mikrasoft a.  
- eco-flam p-260.  
- ph of the total bath a 4-5 (adjusted with citric acid).   
- nip roll pressure: 2 bar   
- temperature in stenter (10 fields): 3x150â°c, 3x140â°c, 2x130â°c, 2x120â°c  
- speed: 8 m/min  
  
in relation with the design, all4restgo2market mattress (demonstrator) was inspired by the âtoppingâ structure and technology previously developed by ecus. this full mattress is a â3-layerâ structure (topping + custom + foundation) which allows end-users to have a customized mattress, in terms of comfort, foam hardness and even transportability and usability (see figure 1).   
  
the fabric structure of the topping layer (further tested by end-users for the final validation of the demonstrator) was established by ecus as follows:  
- top layer. functional fabric pes/celliant finished with pcms.  
- under layer. 3d mesh, fabric made with pes 100%. hypoallergenic and maximizes air circulation and breathability.  
  
in relation with the raw materials involved in the fabrication, 4 main components were considered by ecus:  
- the fibres. two types of pes yarns have been used for it: conventional pes + celliant combined as a weaved structure. rest benefits of the pcms are enhanced with the health benefits provided by the bioceramics included on celliant.  
- the fabric containing pcms. mattress ticking; heavy fabric which contains a lot of filling material.  
- foams used for better comfort and rest quality were similar to use by ecus for other types of mattresses. pur foams were preferred.  
- joining system. for the âfullâ mattress (in a real use) each layer is joined to other with a zip system that ensures no slipping of each layer with movement when sleeping. this system also allows an easy cleaning of the different components.  
  
at the end of this task, a general diagram flux (figure 2) for the all4restgo2market mattress (manufacturing process) was obtained. tests, user-panel and validation along the project were done in the actions contained in the remarked red zone (finishing with pcms and manufacturing of the topping layer).  
  
with the fabrics finished by finipur, ecus was able to develop some âtoppingâ mattresses as demonstrators addressed to the last task t2.4. âvalidation of tests/operational trials in wp2 manufacturing processesâ. co/pes bedsheets from aznar finished with pcms were also included in this validation task. the demonstrator was evaluated/validated in terms of:  
- suitability of the implemented manufacturing process (ok for finipur and ecus industrial processes).  
- quality (pilling resistance and flame retardancy). tested by aitex/ctb.  
- tactile performance.   
- thermoregulation effect and its relation with sleep quality.   
  
a study with real-users testing the thermoregulation properties of the demonstrator (mattress: topping layer) was done, being coordinated by aitex. for boosting thermoregulation properties, this study was also performed using co/pes bedsheets from aznar finished with pcms from devan. the main goal of this study was the validation of the whole (mattress + bedsheet) bedding system developed as demonstrators of the all4restgo2market project (biofiber-based demonstrators not included) for enhancing thermoregulation effect and sleep/rest quality of end-users:  
- study to determine rest/sleep quality (actigraphy was used).  
- thermographic study of the back on end-user and of bedsheets. (figure 3)  
- study of the subjective perception of the comfort given by the mattress (questionnaires were used).  
  
  
   
main results of the study of the thermal comfort and rest given by the all4restgo2market mattress were:  
- actigraphies (when compared with a common mattress) have shown some positive trends in: sleep efficiency (+1,1%); total sleeping time (+5,5%); total time being awake (-4,0%); micro-arousals (total number) (-14,2%).  
- thermographies shown higher thermoregulation effect (temperature variation was +53% buffered); only +0,8âºc in the back zone.  
- body heat was +27,5% retained/absorbed in comparison with a common mattress.  
- this thermoregulation effect was also subjectively perceived by the volunteers (this sensation was +11% perceived).  
  
first task of wp3 was reached with a review of current/novel textile materials for clothes being in contact with the skin. the work done by aitex allowed the consortium to identify biofiber-based (natural) textile materials but also functional synthetic fibres/yarns (with potential skin benefits). more than 15 different biofiber-based materials have been detected as potential to manufacture end-products being in contact with the skin, and also more than 20 different functional synthetics with skin benefits or comfort-enhanced properties (moisture management, thermal insulation, dries faster...): hemp, lenpur, novarel aloe (pa-based), sensifil (pes-based), nylcare (pa-based), nilit aquarius (pa-based) or viloft fibre are only some examples of them. this technical information was also analysed taken into account feedback from consumer surveys coming from wp1. main requirements for knitting/weaving were studied by rapife/aznar (fiber count/length, yarn count range, mechanical resistance / elongation / tenacity) and pre-selection of new biobased materials was done (functional viscose-like types for rapife and aznar) and first pre-trials were done mainly by aznar.   
  
after these pre-trials, partners rapife, ecus and aznar decided to use: seacell/casein (rapife), celliant (ecus) and tencel (aznar); then, in task t3.3 rapife conducted the knitting tests of bio-based yarns in order to develop knitted fabrics for a further confection of pyjamas. it was mainly supported and advised by aitex and ecus. main knitting requirements were established (e.g. yarn count: preferred: 50.000 nm, 50/1). as explained above, a couple of textile materials were considered for the demonstrators: seacell fibre (mixed with cotton in different %) and casein. ctb was also involved looking for suitable yarns.  
  
the scaling-up and running of the knitting process for pyjamas was suitable for all the yarn compositions considered by rapife, but it was found that composition seacell/co 20/80 didnât work in terms of antibacterial activity. then, efforts were focused on textile compositions with higher content of seacell on the final yarn, and also casein was involved in these new knitting tests for further confection (t3.5) of pyjamas. fabrics containing both yarn types were knitted by rapife. structure of the fabric: 1x1, using circular knitting machines. bleaching (following the general recipe rapife uses for their viscose-based fabrics) and dyeing processes were also applied by the company (even finishing in t3.5). (figure 4)  
  
at the end of this task some fabric samples were available for testing properties (tactile comfort, antimicrobial performance, skin irritation, colour fastness, breathability) and also for further confection trials.  
  
in parallel with this work, other industrial partner involved in biofibres developed some weaved fabrics based on tencel. in task t3.4 aznar was in charge of the weaving tests of bio-based yarns in order to develop bed clothes (bed-linen/sheets). it was supported and advised by aitex and ecus. in addition aznar also tested the suitability of a co/pes fabric being finished with pcms from devan (this end-product was tested as part of wp2 demonstrator).  
  
it can be remarked that some previous trials with a special textile material (bio-fibre sofresh mixed with co, looking for a wide range of antimicrobial protection: anti-acne properties, not achieved) were done, and then tencel yarns were selected for weaving bedsheets. tencel was preferred by aznar as an alternative to cotton for manufacturing bedsheets due to good touch and moisture management properties provided. (figure 5)  
  
aznar implemented this textile material in their looms and all the processing steps were validated:  
- yarns with suitable count and mechanical resistance: possible.  
- yarns can be included in a weaving process: possible.  
- development of fabrics: possible.  
- mechanical/chemical/thermal finishes: possible.  
  
next action after obtaining biofibre-based fabrics was the design/trials of required finishing and confection stages (t3.5). finishing and dyeing of knitted/weaved fabrics were performed. no serious problems were detected and rapife/aznar on their new fabrics. finishing with pcms on co/pes was performed by devan/finipur/ctb. last step of this task was the development of the demonstrators through confection processes: knitted fabrics required to be confectioned in order to obtain the end-product (pyjamas). rapife was in charge of this task. more than 20 confection steps were required to obtain the final garment (pyjama formed by t-shirt and trouser). for the weaving fabrics, confection was done by aznar cutting by hand + sewing machines + insertion of elastic bandages; the end-product (bedsheet) was developed to be fitted in a bed/mattress of 150 cm width.  
  
last task of wp3 was t3.6 âvalidation of tests/operational trials in wp3 manufacturing processesâ. finishing processes were considered as validated as no serious problems were found by the partners. the demonstrators were evaluated/validated in terms of:  
- suitability of the implemented manufacturing process (ok for rapife and aznar industrial processes).  
- quality (breaking strength, elongation and pilling). tested by aitex. pilling resistance for tencel fabric was better than cotton.  
- tactile performance. tested by aitex. pyjamas and bedsheets obtained were better than common end-products.  
- antibacterial activity. it was found than seacell/co garment was intrinsically antibacterial against s.aureus and e. coli (99,99% reduction. aatcc-100 test). in addition, it was also found than tencel bedsheet achieved antibacterial activity against s. aureus (99,99% reduction). antifungal activity was not reached. (figure 6)  
  
wp4 started in february 2014 with the development of the commercialization strategy plan. after workshops with the consortium partners and further expert interviews an action plan was developed for the future activities to generate profits from the use of the project results. in the focus was the communication of the rest system approach. this allowed considering the different market positions and strategies of the consortium partner and sharing the costs for campaigns due to the establishment of an association or a society. further evaluation and analysis of various business models by using the results of wp1 and additional interviews as well as adjustments at consortium partners showed that position of the involved project partners are too many different for the selection of one unique business model for all partners and for each partner an individual plan is necessary. the implementation of the business models have been elaborated in cooperation with the consortium partners and for each industrial partner a brief business plan including forecast and action plan was developed.   
  
regarding wp5, the dissemination strategic plan has been performed including the dissemination actions performed and planned and also exploitation issues, knowledge management and ipr issues. the interim and final plan for the use and dissemination of the foreground including the exploitation agreement have been finalized. on the other hand the consortium has performed several dissemination activities in fairs, events, articles and meetings with future customers. also a leaflet and a poster have been developed for being use as dissemination tool. a website has also been created, also in order to reach the most people, social networks have been used such as linkedin and facebook. the companies have also disseminated the project among their potential customers and also in specific campaigns with prescriptors, sport practisers and hotels.  
  
regarding wp6, project management is also in progress since the beginning of the project. among the main activities performed were the signature of the consortium agreements, the transfer of the pre-financing and mid-term funds, the organization of six consortium meetings and also the organization or conference calls for monitoring the work and a list of actions updated for the same purpose.  
  
potential impact:  
all4restgo2market has achieved all of its objectives and technical goals with relatively minor deviations along the project. regarding wp1, the consumer segments have been analysed. the main four segments are âcustomer with rest problemsâ, âendurance sports athletesâ, âjob performerâ and âgeneral interested consumersâ (ms1). within the named segments the identified usp is a rest system approach. the market potential including all components of a rest system has been quantified at a volume of 1.16 bn â¬ on eu27 level for the next 10 years (ms2).   
  
in wp2, demonstrators of textile products addressed to rest systems were obtained: mainly mattresses but also bedsheets, both finished with pcms. validation of the thermoregulation properties and their relation with rest quality was done (ms3), and s/t objectives regarding types of fabrics to be finished and improvement on the thermoregulation effect were achieved (expected: 15%; reached: 27,5%). in addition, it was found that a methodology to study thermoregulation on rest systems can be developed (even deeper studies could be realized, but duration of them should take several months and involve more people -conditions of the evaluation should strictly be controlled-). further industrialization and commercialization should: a) take into account feed-back in relation with design of the end-product (design -even in packaging- is important for buying); b) give comprehensible info about technical and healthy properties of the mattress.  
  
in wp3, demonstrators of textile products for sleeping -that are in direct contact with the skin- were obtained: pyjamas and bedsheets with biofiber-based yarns. knowledge on new textile materials/fibers for clothing being in contact with the skin was reached by textile companies (ms4) even for a wide variety of biofibres and compositions (up to 6 were investigated; 3 were successfully validated). (figure 7)  
  
validation of each manufacturing process and sub-processes (finishing/confection) was achieved (ms5/ms6). determination of improved tactile comfort was evaluated through kawabata test, and it was found even higher than expected (expected: 15%; reached: 11-15% for pyjamas, 62% for pyjamas) in comparison with common textile materials like co or co/pes. the obtained fabrics maintain the intrinsic antibacterial properties the yarns have (e.g. for seacell-based compositions). soft touch of the fabrics can be appreciated by customers and other general properties affecting the quality of pyjamas (mechanical resistance, pilling, breathability or colour fastness) were in the expected range. bedsheets were validated in terms of processability and enhancement of feeling, touch and soft handle. even it was found that the bedsheet produced shown antibacterial performance against s.aureus (silky touch of the fabrics could be appreciated by end-users for purchasing, and technical properties in relation with comfort were also subjectively perceived: handle, freshness and general comfort given). other general properties are in the expected range.  
  
in wp4 various business models (combinations of the rest system products) has been evaluated and alignment with the global company strategy assessed (ms7). a general commercialization strategy to increase the perception of the rest system approach has been defined by the establishment of a rest system community. in addition to the common activities of the general commercialization of the rest system approach for each industrial partner a business plan has been developed. the cumulated forecast of the industrial partners will be near to 10 mil â¬ over the next three years (ms8).   
  
the consortium has given big importance to the dissemination and exploitation activities and therefore they have drafted a strategic dissemination plan, all the dissemination activities were focused mainly in potential customers and other related stakeholders, media such as articles publications, dissemination in related congresses, fairs, meetings with customers, department stores, fitness centres, prescriptors, hotels, sporters, participation in sport events, leaflet and posters creations and also publications social networks have been used.  
  
at the end of the project, the three products developed were assessed and also their thermoregulation and comfort properties, a business plan per company and a commercialization strategy were drafted and also an exploitation agreement.  
ecus is beginning the commercialization of the mattresses developed, devan also is commercializing their pcms and the other companies will start in a near future.  
  
the developed research generates high societal and market impact for the european smes, and enable major technological breakthroughs.  
  
the address of the project website is: http://all4restgo2market.com  
  
a video showing the products obtained can be seen in the following link: https://drive.google.com/file/d/0b189rimhsmviaxq3wgg3wha0a2m/view?usp=sharing  
main dissemination activities and exploitation of the results.   
the project dissemination activities have been consistent with the originally planned, as well as with the dissemination strategy. the partners, have used an array of mediums and tools in order to successfully disseminate the project to the relevant audience. the presentation of the semi industrial prototypes and other relevant technology has been available for partners and has been promoted to potential customers, prescriptors, future sellers, end users and other stakeholders. in order to raise public awareness of the proposed technology, the partners have performed pre-marketing stimulation activities such as editorials, conference papers, sales, presentation in fairs and marketing contact with potential customers internationally, through the use of trade press, trade bodies and plant suppliers, approvals bodies, consumer groups and regulatory authorities. activities include technology demonstration events, major exhibitions, stimulation events, presentations and conference papers and the distribution of project promotional material.  
below, it is explained a detailed list of all dissemination activities (publications, conferences, workshops, web sites/social networks, press releases, posters and flyers, articles published, media briefings, presentations, exhibitions).  
events   
the project was noted with overall success in relation to the participation of the partners in events. a variety of different events took place such as conferences, participation in exhibitions and fairs as well as participation in seminars. the semi industrial prototypes and the technology of the project have been presented thoroug ...

# ELECTRICAL

Project Acronym: ELECTRICAL

programme & topic: FP7-TRANSPORT AAT.2010.1.1-2.;AAT.2010.1.1-4.

Most frequent returning words in objectives:

* ('resin', 39)
* ('project', 35)
* ('cnts', 30)
* ('cfrp', 27)
* ('conductivity', 25)
* ('incorporation', 25)
* ('development', 24)
* ('technologies', 22)
* ('bulk', 19)
* ('materials', 18)
* ('structures', 17)
* ('doped', 15)
* ('arkema', 15)
* ('laminates', 14)
* ('carbon', 13)
* ('order', 13)
* ('process', 13)
* ('part', 13)
* ('processes', 12)
* ('nanofillers', 12)
* ('resins', 12)
* ('liquid', 12)
* ('work', 12)
* ('fibres', 12)

executive summary:  
the main objective of electrical is the development of novel multifunctional composite structures with bulk electrical conductivity and self-sensing capabilities for rapid non destructive quality assessment.   
the project exploits properly the excellent properties of cnts as polymeric resin doping for the development of novel multifunctional composite structures with bulk electrical conductivity and self-sensing capabilities.   
  
electrical investigates and developes alternative emerging methods to manufacture nanoreinforced carbon based composites compatible with current industrial manufacturing processes of composites: incorporation of nanofillers into toughening thermoplastic fibers, non-woven veils, incorporation of nanofillers into nanostructured preforms called buckypapers, incorporation of nanofillers in injection resin and carbon fiber prepregs.   
  
electrical incorporates the following scientific and technical objectives:   
  
a)improvement of bulk electrical conductivity of aeronautical composite structures to meet requirements regarding static discharge, electrical bonding and grounding, interference shielding and current return through the structure. the technical approach will be based on the conductive properties of carbon based nanoreinforcements when integrated into the laminates.  
at the same time, a global electrical conductivity test method will be defined and set-up in order to have a common understanding: standardisation of electrical measurement and assessment procedures.  
b)monitoring and optimisation of cfrp curing process by dielectric mapping. taking advantage of the electrical conductivity of cnts, the dielectric sensor system mounted in the mould will perform non invasive measurements of the electrical properties of the material in the sensorâ´s vicinity for material-state monitoring (degree of cure, tg), resin flow in moulds (arrival time, flow speed and direction) and end-of-cure detection.  
c)taking advantage of the piezoresistive behaviour of cnts, development of innovative cfrp structures with distributed or localised self-sensing capabilities for quality assurance of final component (delaminations, inclusions, etc) by electrical resistance tomography (ert)  
d)development of state of the art fabrication technologies to convert nanofillers (cnts and others) into engineered multifunctional preforms, prepregs, buckypapers, etc.., for further use in cfrp structures. cnts bulk doped resins are also to be considered as the main base-line for investigation in the present project. synergistic effects of using bulk doped resins and new developed engineered structures will also be under investigation.  
e)manufacture, characterisation and testing cfrp based materials with such multifunctional engineered nanostructures and bulk doped resins. the most broadly used liquid moulding technologies will be considered, although autoclave curing and associated prepreg development will also be considered as the base line.  
f)manufacture and testing of representative panels/prototypes for proof-of-concept of the materials and technologies developed.   
g)health, environment and safety issues derived from cnt handling will be specially considered in the project. partners will be trained in the processing of nanomaterials in laboratory and industrial environment, which is a major issue in current development of these technologies.   
  
project context and objectives:  
based on the needs to provide advanced concepts and technologies for increased and optimised use of light-weight composite smart materials, the main objective of electrical is the development of novel multifunctional composite structures with bulk electrical conductivity and self-sensing capabilities for rapid non destructive quality assessment  
  
the main challenges of the project can be summarized as follows:  
this project for the first time allows the transition from improved nanoreinforced resins to the exploitation of their enhanced electrical and mechanical properties in full laminates manufactured by automated processes. as such, next generation aircraft structures can be estimated to be approximately 5% lighter than using boeing b787 or airbus a350xwb technology. furthermore, synergy effects with other markets, such as sports goods, automotive, packaging and semiconductors could benefit significantly.  
research and technology development on nanoreinforced resins has been performed under public contracts for several years. however, cost efficient infusion technologies have to date not been able to be used with these resins primarily due to particle filtering during injection. it is the aim of this project to overcome this critical bottleneck by assessing and driving alternative nanoparticle introduction techniques as well as establishing processing windows for âtraditionalâ nanocomposite formulations.  
therefore, it is established, as main technological challenge for electrical, to increase electrical conductivity through-the-thickness of aeronautical cfrp laminates. achieving this would enable an important reduction of the overall airframe weight by replacing current metallic structural network (metal mesh). in order to achieve that, several methods for introducing electrically conductive nanofillers into cfrp laminates have been assessed, establishing the use of bulk doped resin as a baseline for investigation, but developing new engineered nanomaterial based structures that would overcome problems of filtration and re-agglomeration. differently from other current ongoing projects, where surface conductivity is the main issue for other functionalities, electrical is focused on electrical conductivity through the laminate thickness.  
in terms of mechanical properties, significant improvements in impact behavior are expected in addition to electrical conductivity, leading to a reduced burden on the environment by air travel. more importantly, allowing the consideration of cfrp bulk conductivity in aircraft design will lead to new aircraft architecture concepts with further weight savings and performance increases. in addition, potential self-sensing techniques can reduce unscheduled and scheduled inspection times and will allow a rapid quality assurance and enhanced manufacturing process control, revolutionizing cfrp manufacture.  
  
the project exploits properly the excellent properties of cnts as polymeric resin doping for the development of novel multifunctional composite structures with bulk electrical conductivity and self-sensing capabilities. for that, different lines of work will be approached:  
  
firstly, this project investigates and developes alternative emerging methods to manufacture nanoreinforced carbon based composites compatible with current industrial manufacturing processes of composites  
  
in particular, polymer injection processes will constitute the main projectâs target, this including rtm, rti, lri and their variants, although autoclave curing is to be considered as the reference process. during the life of the project the following topics of research have been considered:  
â¢ incorporation of nanofillers in dry carbon preforms.- the use of performs is typical when modern liquid composite moulding technologies are used; on one hand due to the necessity to incorporate toughening thermoplastic fibres and veils, and on the other hand due to the necessity to automate the process. this project investigates which technologies would enable the incorporation of nanofillers in these preforms before resin infiltration, mostly looking at the addition of nanofillers in between structural fabric layers in order to promote through-thickness conductivity. this way, the increased viscosity of the resin and the filtration effect when nanofillers are incorporated directly into the resin can be avoided. several approaches have been tackled:  
- incorporation of nanofillers into toughening thermoplastic fibres. one route to provide an increase in toughness for brittle resins used in liquid injection technologies is the use of thermoplastic fibres that are introduced into the textiles used for the reinforcement. this can be achieved by co-weaving or more effectively by commingling structural fibres with tough thermoplastic fibres prior to the weaving of the fabric. the thermoplastic fibres can then, either dissolve in the thermosetting resin after infusion and during cure, or they can remain in the final composite as a solid fibre. also the fibre can be used for a secondary stitching of standard structural reinforcements. the possibility of doping thermoplastic fibres with cnts has been addresses in this project.  
- incorporation of nanofillers in polymeric non-woven veils. another route to provide an increase in toughness is the use of an ultra-thin veil. during the resin infusion stage these veils are dissolved in the thermosetting resin. the incorporation of cnts into the thermoplastic before producing the veils enables a better and more homogeneous incorporation during the infiltration.   
â¢ preforming cnts into thin mats with well-controlled dispersion and porous structure, so called âbuckypaperâ  
â¢ incorporation of cnts in injection resin. alternatively to the incorporation of cnts in dry carbon preforms, the incorporation of cnts in the bulk liquid resin is also considered. the target of the project in this case is established on how to overcome the still pending technical challenges: optimal and stable dispersion of cnts into the resin so that the mixture can be stable across time without any re-agglomeration effect, suitable cnts/resin interfacial bonding and preserving integrity of cnts during dispersion process.  
â¢ modified or new injection strategies.-. the incorporation of cnts into injection technologies, either into dry carbon preforms or as a buckypaper or into the bulk resin, will require at least a modification of injection processes, even in some cases the set up of new injection strategies. in the case of dry carbon performs or buckypaper the fibre permeability will be modified, while in the case of doped bulk resin the viscosity increase will modify their flow and filtering effect; at the same time than changing the curing kinetic of the polymer. among others, the following strategies will be investigated as potential solutions:  
- tuning of process parameters for traditional technologies. this task would concentrate on the development of technical solutions to overcome the problem of viscosity increase and filtration above described: optimization of temperature and/or pressure, modification of mould configuration (injection gates and vents), flow media, textile/performs permeability, etc.  
- two step infiltration for rtm and lri. the possibility of using the rtm or other liquid resin infiltration methods with cnt-doped resins has been investigated in the past with very poor results. the fiber preform is essentially acting as a filter, preventing the cnt particles from spreading along with the resin inside the preform, effectively keeping them in a small area around the injection nozzles. an alternative 2-step process that can eliminate these problems has been studied in laboratory conditions. the process involves pre-functionalised fiber preforms and use of a carrier liquid (aqueous or organic solvents) of very low viscosity in which the cnt's are dispersed.  
â¢ alternatively the incorporation of cnts into carbon fibre pre-pregs is considered. as above stated, filtration phenomena occurred during infiltration of performs with doped resins is a major problem yet to overcome. the strategy to be addresses within the project is the production of carbon fibre prepregs with doped resins. the incorporation of cnts into prepreg for further production of laminates would enable electrical conductivity enhancement along the âzâ axis of the laminate; the project analyses how the addition of cnts can modify the prepreg processing along the different steps (resin doping, prepregging, storage, handling / lay-up and curing) to understand the processing of three phase composites with cnts and their influence on final performance.   
  
the prepreg technique requires a high viscosity resin that undergoes minimal flow, which reduces the mobility of cnts during the curing process and therefore their possible re-agglomeration during this phase. however, the processing side-effects can not be completely ruled out because previously cross-linking is initiated by chemical reaction, the resin undergoes a minimum viscosity level. the influence of cnt content must be evaluated.  
  
secondly, the multifunctionality concept is approached, which consists of the integration of three main functionalities:  
â¢ increase of electrical conductivity of cfrp laminates for indirect lightning strike protection, static discharge, electrical bonding and grounding, interference shielding and current return through the structure. standardisation of electrical measurement and assessment procedures.  
â¢ monitoring and optimisation of cfrp curing process by dielectric mapping. in order to monitor and optimize the process dielectric sensors will be incorporated in the mould used for cfrp curing. this technology, previously developed under the framework of different r&d projects, has been adapted to the materials and processes to be studied along the project.   
â¢ quality assurance of final component (delaminations, inclusions, etc) by electrical resistance tomography (ert). this will be achieved by the integration of cnt fibres into the cfrp laminates. more precisely, this technology will be based on pvs/cnt fibres stitched on the standard structural reinforcements; the nano-doped fibre can act as distributed conductivity sensor for ndt using ert  
  
description of work  
the work breakdown structure defined to meet the main technological challenges and objectives is based on seven work packages, going forward through the main challenging tasks from definition of specifications towards manufacturing issues, testing and evaluation. six work packages were devoted to technical matters, while the seventh will deal with coordination and managerial issues, as can be seen in the following diagram:   
wp1 is devoted to the definition of targeted component types (composite structural part) and their specifications. this constitutes the base for a preliminary selection of materials (polymers and cnts) and manufacturing processes.   
  
the development of strategies for cnts incorporation into laminates is approached in wp2. the structures here developed constitutes the basis for further incorporation into composite components. two main approaches are considered during the first half of the project until month 18, the first one based on the incorporation of cnts into thermoset resins for liquid technologies (rtm, etc) or prepregs (autoclave), and the second one based on innovative structures like cnt buckypapers, or dry performs based on cnt doped thermoplastic fibres, veils or films.  
  
in this wp, a specific milestone has been established in month 18 as a preliminary review in order to assess technical achievements regarding electrical conductivity, mechanical performance, etc in order to select the most promising strategy for the applications considered. the second half of the wp and project focuses all the efforts in those most promising materials and technologies.  
  
wp3 deals with nanoreinforced composite production through liquid infiltration technologies, as the main route, and autoclave curing as an alternative short-term manufacturing method (risk reduction).   
  
in parallel to wp2 and 3, the wp4 is devoted to the characterisation of composite laminates produced, mostly for electrical conductivity, and development of the sensing and damage detection approach. furthermore, parallel structural tests are carried out in order to evaluate how the nanofillers affect to mechanical properties.  
  
multifunctional composite with electrical conductivity and sensing systems developed in wp4 are validated in wp5. for that, representative scaled structural components incorporating the cnt-structures were designed, fabricated and technically evaluated in order to provide guidelines for optimal design. moreover, safety and security aspects were considered.  
  
the commercial evaluation of products obtained from previous develop will be carried out in wp6, in order to assess the potentialities to transfer to real applications. the diffusion and exploitation aspects will also be undertaken to address future activities and to establish a roadmap for the quick introduction in the market of the structural concept developed in the project  
  
project results:  
3. description of the main s&t results/foregrounds  
  
wp1. requirements. specification of materials, processes and targeted components  
  
the objectives for this wp are:  
â¢ to precisely define the input data necessary to manage the whole technical issues: targeted component types (composite structural part) and their mechanical and electrical specifications, materials (polymers and nanomaterials) and manufacturing processes, (prefroming and laminate manufacturing), working program and configurations to be developed and evaluated  
â¢ to define a global electrical conductivity test method in order to have a common understanding: standardisation of electrical measurements and assessment procedures  
  
the technology to be developed in the project to achieve the main goal of developing novel aeronautical multifunctional composite structures with bulk electrical conductivity and self-sensing capabilities for rapid non destructive quality assessment, is the nanoreinforcement of cfrp airframes.  
  
 definition of target parts  
electrical, as fp7 level 1 project, aims at contributing to mature the nanocomposite technologies for electrical application in aeronautical field, to trl, technology readiness level, 2-3. therefore, in this project the demonstration is planned at the level of stiffened panels, which will be representative of the selected structures (wing, fuselage).  
  
 wing   
â¢ composite structure: skin, stringers, ribs, ...   
  
figure 1 â wing structure   
 fuselage section   
â¢ composite structure: skin, stringers, frames, ...   
â¢ low level electrical function esn parts (metal): frames, cross-beams, race-ways, ...   
   
figure 2 â fuselage structure   
  
requirements  
first priority objective of electrical project is the improvement of the aeronautical cfrp structure electrical behaviour with the final aim of weight saving. the mechanical behaviour of cfrp structure at least needs to be maintained, being the mechanical enhancement in second place. therefore, electrical requirements to be met by the nanoreinforced laminates to be developed in this project are key.   
the following electrical constraints to be sustained by the aeronautical cfrp structure were identified. a detailed description is compiled within deliverable d1.1&d1.2  
  
a)lightning strike: direct and indirect effects  
the requirement for the resistance per square of future cfrp fuselages will be between 1 and 6 mî© per square   
  
b) edge glow (cfrp edges), sparking (cfrp bolted joints)   
during some lightning strike lab tests on coupons made of last generation thermoset matrix like the m21e, some sparking have been observed on the coupon edges. this phenomenon, which is called edge glow, must be avoided in fuel tank areas  
  
c)electrical bonding: handling of electrical current due to a short circuit inside a system   
the electrical bonding is the return of fault, defect currents in the aircraft. the path of the bonding current circulates through structural cfrp elements. currently a specific metallic network is used for new generation aircrafts with cfrp fuselage to carry out this function. the network is named mbn (metallic bonding network).  
this network usually merges with the metallic structural parts like seat-tracks to perform an aircraft mesh which permits to evacuate the function and fault currents of the different systems, the full network in fuselage area is the esn (electrical structural network).   
nevertheless, it is necessary to add specific components (metallic strips) to each frame and crossbeam of the aircraft to insure the electrical continuity answering to the global specifications of all the systems. the sum of the elements constitutes a complex mesh like the virtual mock-up bellow  
for the electrical bonding function, a current of 2000 a for 300 ms needs to be considered  
  
d) short circuits between wire and cfrp   
the short circuit involves the direct contact of an electrical wire with the cfrp.   
3 different short circuit issues have been identified:   
â¢ direct on cfrp   
â¢ bundle exploded near the cfrp   
â¢ behavior of cfrp junctions submitted to a failure   
  
e)electrical grounding: systems functional current return   
the electrical grounding is the systems functional electrical current return. electrical current return refers to the establishment of a low impedance current path between the power supply reference (0 v dc, 0 v ac or ac neutral) of an electrical component and the aircraft point of voltage reference.   
for electrical grounding, the following requirements need to be considered:   
- continuous electrical currents: low: 10 a, medium: 20 a, high: 200 a   
- this current shall not lead to a resin temperature increase above a temperature at least 28â°c below the resin tg   
- electro-thermal aging   
  
in the following table a raking of the electrical functions to be covered and aimed at by the nanocomposite technology within the electrical project is shown. this ranking was performed taking into account the electrical requirements and, then, the probability of success.   
   
ranking of electrical functions  
  
materials and processes  
the materials and processes selected for the project are:  
laminate materials  
  
thermoplastic preform materials  
one of the key research lines of the electrical project to obtain nanoreinforced infused laminates is the introduction of cnt in the infusion textile preform thermoplastic materials (veils), with the main aim of avoiding filtering problems associated to the nanodoped bulk resin infusion.   
the following requirements need to be met by the nanodoped thermoplastic materials to be introduced in the infusion textile preform:   
  
key requirements   
â¢ no wash-out: poor solubility in the laminate matrix at the infusion temperature (120â°c) during the infusion time (120 minutes / 2 hours)   
â¢ good adhesion to the laminate matrix after cure.   
â¢ no negative influence on thermo-mechanical properties (hot-wet)   
â¢ binding parameters: veil target weight: 6 g/m2 for 268 g/m2 ud cfrp layer   
  
a complete compilation of potential thermoplastic materials to be used as nanocarriers was done (refer d1.1&d1.2). from this table the following thermoplastic material was selected: platamide copolyamide (arkema). two grades: 110âºc and 135âºc melting temperature. it is important to remark that the selected material should perform both functions: nanocarrier and binder. additionally, some basic infusion trials will be done by eads iw - g with higher melting temperature polyamides, supplied by arkema: pa6 (210 âºc) and pa12 (176 âºc).  
  
nanomaterials  
the cnt selected for the project are compiled in the following table.   
  
system selected material  
cnt masterbatch:  
first priority â¢ platamid (copolyamide): fibers and veil application to be supplied by arkema  
â¢ mvr444/ef6809: premixture to be supplied by cytec to arkema to produce a masterbacth  
â¢ cw245: cmc (carboxymethyl cellulose) based masterbatch to be supplied by arkema  
 mwcnt  
powder â¢ arkema-c100: for nanodoped prepreg production by patras university and for buckypaper production by tecnalia  
  
testing  
electrical testing   
  
the proposed electrical test methods are compiled in the table below. as for the electrical conductivity, it is important to remark that it is a goal of this project to develop an appropriate test method. however, as these measurements are needed in the project early phase in order to assess the value of the different techniques before entering the phase of the listed tests, appropriate test methods have been identified to carry out these measurements.  
   
lightning strike direct effects on fuselage panel   
the behaviour of the investigated material under lighting strike shall be compared to the one of the current baseline, i.e. the a350-900 fuselage skin configuration.   
the a350-900 baseline for the fuselage skin is the following one:   
 9 plies of m21e/ima, faw: 194 g/m2, rc: 34%, lay-up: [45/0/135/90/0/90/135/0/45]   
 expanded copper foil, aw: 195 g/m2, impregnated by 170 g/m2 of surfacing film   
  
top layers:  
the external paint system shall be representative of the a350xwb-900. the targeted external paint system thickness will be about 330 î¼m. with such a thickness and taking into account around 30 î¼m of basic primer and 90 î¼m of surfacing film on top of the ecf, the total thickness on top of the ecf should be around 450 î¼m.   
sample dimensions:  
for lightning strike tests at the lcoe lab (getafe, spain) or at lightning technologies (culham, uk), the samples shall have the dimensions presented in figure 12.   
for lightning strike tests at the dga-ta, the dimensions of the samples need to be indicated by the relevant specialists.   
  
mechanical testing   
the proposed mechanical tests in the project are compiled in the following table. these tests should be done at room temperature, that is hot/wet tests will not be carried out, due to the relatively low trl of the electrical project.   
  
physico-chemical testing   
the proposed physico-chemical tests are included in the next table.  
  
non-destructive ultrasonic inspection of all the manufactured panels / specimens were carried out in order to ensure their quality.   
microscopy evaluation (sem) was performed to assess the quality of the nanomaterial dispersion in the manufactured panels / specimens. more detail information can be found within d1.1 (definition and requirements of structural parts) and d1.2 (definition of materials and processes).   
  
wp2. development of strategies for incoporation of cnts   
this work package aims at the development of strategies for the incorporation of cnts into the composite laminates, which constitutes the basis for further incorporation into composite components. different approaches for cnt incorporation were considered:  
â¢ incorporation of cnt into thermoset resins for liquid technologies (rtm,etc) or prepregs  
â¢ incorporation of cnts as innovative structures like buckypapers, or dry preforms based on doped thermoplastic fibers, veils or films.  
  
due to concern related to the use of nanomaterials, health, environment and safety issues derived from cnt handling were specially considered in the project. partners were trained prior to the start of the activities related to the handling and use of nanomaterials in both laboratory and industrial environment since it is considered a major issue in the current development and uptake of these technologies. a security training course for the handling of nanomaterials and in particular carbon nanotubes (cnt) materials was organised. this training course took place during the electrical meeting organized in france by arkema at the research center of lacq (grl) in october 2011. canoe organized this training course in collaboration with arkema. this training course was organized for a day and was composed of 5 parts:   
  
- 1st part : general aspects of nanomaterials and nanotechnologies (by pr daniel bernard) : 8h30-9h00   
- 2nd part : regulation and normalization at international level (by pr daniel bernard) : 9h30-10h00   
- 3d part : health and safety at work station/metrology and characterization problems (by serge bordere, arkema) : 10h00-10h45   
- 4th part : visit of grl work stations : 10h45 â 12h30  
- 5th part : discussions with partners : 12h30-13h00  
the 6m progress meeting was deliberately held at arkema in order to include the security training ahead of the main scientific programme. eventhough it was scheduled within wp5 the consortium considered to celebrate the workshop at the earliest possible date (see d5.3).  
  
in wp2 two major technologies are approached. each of them covers two research lines where different partners took part:  
â¢ bulk resin doping  
o 2.1a liquid technologies (doped resin)  
 cytec, arkema, tecnalia, bombardier  
o 2.1b prepreg development  
 cytec, arkema, uop  
â¢ novel engineered structures  
o 2.2a dry preform development  
 arkema, canoe, tecpar, tecnalia, eads-iw-g, bombardier  
o 2.2b buckypaper development  
 tecnalia, uop, bombardier  
the work carried out in wp2 during the 36 months of the project is contained in the 1st and 2nd periodic reports. the following paragraphs intend to give a general overview of objectives, activities and results obtained in this wp.  
  
bulk resin doping  
liquid technologies  
the activities of tecnalia have been focused on the development of cnt doped resin to be used in composite laminates manufacturing by liquid technologies. tecnalia has been working in close cooperation with cytec for the development and supply of the mvr 444 resin in two parts and with arkema for the development of cnt masterbatches. in summary the activities related to bulk resin doping answer to three approaches:   
-approach 1: the mb based on part a of the mvr444 resin (extrusions)  
-approach 2: two mb based on mvr444 (a+b) containing 25%wt of cnts, in two formats: pellets (p) and granules (g)  
-approach 3: for this approach, the mb based on part a of the mvr444 resin (approach 1) was converted to pellets by arkema.   
the work performed in the frame of this activity (masterbatches treatment, characterization ârheology, electrical and mechanical- is carefully described in d 2.6. main conclusions of the work carried out in the doping of epoxy resin with part a based masterbatch in pellet form, it can be summarized as follows: electrical conductivity of e-6 s/m is obtained with 0.1 wt.% cnt. this conductivity value is similar to that obtained with cnts in powder form, and approximately 4 orders of magnitude higher than the conductivity obtained with the previous masterbatches. rheological results reveal that the quality of dispersion is good and carbon nanotubes have an accelerating effect in the curing of epoxy resin. however, the nanocomposites based on this nanomaterial show narrower processing window than that required by bab.   
  
prepreg developement  
uop lead this task along with support from cytec. objective of this wp was to develop various strategies for the incorporation of cnts into the composite laminates, which constituted the basis for further incorporation into composite components.  
the process development plan agreed (11/01/2012) that takes into account cytec material ip limitations consists of three (3) distinct routes:  
route 1 (direct doping): direct doping of ef6809 resin system used to produce cytec pre-pregs. part a of ef6809 is shipped to uop where the cnt dispersion was performed. cnt doped part a of ef6809 is returned to cytec where complete ef6809 formulation is created. this cnt-doped ef6809 resin system is used by cytec to produce a cnt-doped ef6809 pre-preg.  
route 2 (resin film treatment): cnt- treatment of conventional ef6809 resin films of cytec. fully formulated resin film (ef6809) is shipped to uop. uop using various cnt deposition/integration techniques produces cnt treated ele-ef6809 film.  
route 3 (prepreg treatment): cnt-treatment of conventional ef6809 prepreg materials of cytec. conventional ef6809 pre-preg is shipped to uop. uop using various cnt deposition techniques produces the cnt-treated ef6809 pre-preg. two bacthes were manufactured with the second having improvements over the first  
all the activities uop performed for the development and manufacturing of cnt treated prepreg are compiled within d2.6  
novel engineered structures   
dry preform development  
nano-doped fibres  
  
the activities performed by canoe followed the objectives:  
- fibers fabrication based on thermoplastic and thermoplastics co-polymers (different grades of copolyamide were prepared and doped with cnt by arkema) with different weight fractions cnt,   
- optimization of the fibers processing methods by extrusion process  
- characterization of mechanical and electrical properties of these fibers and tecpar manufactured fibers  
the activities related to canoe are compiled within d 2.6  
  
canoe developed and adapted the fabrication line of the fibers for cnt doped fibers. the work carried out by tecnalia involved the stitching of cnt doped fibres into carbon fibre panels as a means of introducing cnts into the bulk of the composite. eads iw germany performed trials using a tufting r ...

# BIONEXGEN

Project Acronym: BIONEXGEN

programme & topic: FP7-NMP NMP-2009-2.6-1

Most frequent returning words in objectives:

* ('membranes', 44)
* ('cnts', 43)
* ('membrane', 36)
* ('water', 30)
* ('wastewater', 23)
* ('bionexgen', 19)
* ('partners', 18)
* ('rejection', 16)
* ('results', 16)
* ('project', 15)
* ('groups', 15)
* ('experiments', 15)
* ('model', 14)
* ('tests', 12)
* ('novel', 11)
* ('process', 11)
* ('textile', 11)
* ('forth', 11)
* ('cell', 11)
* ('period', 10)
* ('hska', 10)
* ('mill', 10)
* ('incorporation', 10)
* ('data', 9)

executive summary:  
according to the world health organisation (who), the most dangerous threat for health of mankind emerging within the next years is polluted water. though polluted water and water shortages demand for a sustainable water usage and recycling of wastewater, the barriers are high to adopt these outside of europe: clean water as basis for health and good living conditions is too far out of reach for the majority of the population. thus, neither sustainable consumption nor reinforcement of governmental regulations are effective drivers to force the industry to adopt sustainability policies.  
membrane bioreactor (mbr) technology is regarded as a key element of advanced wastewater reclamation and reuses schemes and can considerably contribute to sustainable water management. mbr technology is used for wastewater treatment and reuse in municipal, agricultural and a variety of industrial sectors in europe and middle east and north africa (mena).   
the overall objective of bionexgen is to develop and test on pilot scale a new class of functional low fouling membranes for membrane bioreactor technology with high water flux and high rejection of organic pollutants with low molecular weight. the field tests with these newly developed membranes will be carried out with wastewater from 3 different industries (cosmetics, textiles and olive oil industry) which play an important role in the mena countries and will be compared to conventional, commercially available membranes for benchmarking.   
the consortium will develop a novel single step nano-filtration (nf) mbr operated with low energy consumption; small footprint, flexible design, and automated operation make it ideal for localized, decentralized wastewater treatment and recycling in the european and mena countries.  
  
project context and objectives:  
the overall objective of this project period was first of all to continue providing basic benchmarking data for all bionexgen r&d activities. to this end benchmarking pilot trials using the existing mn membrane and practical industrial wastewater have been pursued by the partners cmrdi, cbs and hska. besides that laboratory work on novel membrane materials such as pbm coating, cnts and layer-by-layer technology has been conducted. cost estimate for the potential bionexgen manufacturing process has been carried out. moreover computer modelling and laboratory activities continued with focus on modifying the existing commercial mn membrane. the emphasize was given on theoretically studying structures-properties relationships of cnts and incorporating vertically aligned cnts in the existing mn membranes as well as casting a novel nano-scale layer with tailored pore size onto the membrane surface. characterisation of novel membranes regarding surface morphology, water flux and rejection of model compounds were conducted. preparation of technical module envelopes for pilot trials in mena countries were done. finally field tests using these novel membrane based modules were carried out with textile wastewater, olive mill wastewater and cosmetic wastewater and the results were reported in different deliverables.  
  
the specific objectives of the project were:  
  
wp1:  
â¢ securing benchmarking data with existing mbr modules in short term by running small-scale pilot units with real wastewater from olive mill, textile and cosmetics industry.   
â¢ preparation of a systematic market research for mbr application  
â¢ defining potential membrane, module and process chemical materials under economic, technical and health related constraints  
â¢ conducting laboratory tests (water flux, rejection) with membrane samples with pbm coating prepared by itm-cnr  
â¢ update of cost estimate for potential bionexgen pbm membrane manufacturing process as well as layer-by-layer technique in cooperation with itm-cnr, forth and iztech  
  
wp2:  
â¢ structures-properties relationships related to organic solutes rejection from cnts as well as theoretical study of water flow through cnt doped mn membranes.  
  
wp3:  
â¢ incorporation of cnts in the existing mn polymer membranes by filtration in combination with tip sonication  
â¢ functionalization of cnts by hydroxyl groups  
  
wp4:  
â¢ synthesis of polymerisable surfactant for pbm technique  
â¢ modification of the existing mn membranes towards nanostructured membranes with tailored pore size by pbm techniques.  
â¢ provision of flat sheet membrane samples for laboratory tests on water flow and solute rejection  
  
wp5:  
â¢ starting initial experiments to synthesis antimicrobial nanoparticles  
â¢ modification of the existing mn through layer-by-layer technique in order to increase antimicrobial properties  
â¢ continuation of experiments to synthesis antimicrobial nanoparticles  
â¢ provision of antimicrobial nanoparticles for being incorporated in layer-by-layer coating  
  
wp6:  
â¢ laboratory activities to study surface and cross sections of membranes to gain: surface roughness measurements, characterisation of surface morphology, changes to cross section of membranes and foulant layer thickness.  
â¢ characterisation of novel membrane samples with regard to water flux and rejection of model compounds  
  
wp7:  
â¢ preparation of technical module envelopes for upcoming pilot trials in the mena countries. the main focus was on selection of a low-temperature glue for lamination process of the envelopes since the novel pbm membrane material is not as temperature stable as the commercial material.  
  
wp8:  
â¢ to conduct field tests with olive mill wastewater  
â¢ to conduct field tests with textile effluent  
â¢ to conduct field tests with cosmetic effluent  
  
apart from r&d wps, specific objectives were also set for the wps dedicated to the following activities: dissemination, exploitation (wp9) and management (scientific (wp10), administrative and financial (wp11)).   
  
wp9:  
â¢ to create the first step-stones for marketing activities necessary for the exploitation of the projectâs results  
â¢ to give visibility of bionexgen objectives, activities and benefits by answering to the different needs of target groups   
â¢ to disseminate bionexgen aims, evolution and results through printed (brochures, booklets, etc) and electronic (website, quarterly electronic newsletter) sources.  
â¢ to manage the access to partnerâs background ip necessary for the project  
â¢ to manage and protect the consortiumâs foreground ip   
â¢ to avoid patent infringement  
â¢ to assure a successful technology and knowledge transfer between the academic partners and the smes  
â¢ to create interest in the bionexgen concept from potential customers in europe as well as in the mena region  
â¢ organisation of the first training workshop focusing on basic principles and state-of-the-art of "membrane based wastewater treatment and reuse" at cbs in sfax, tunisia. this workshop took place on the 8th and 9th of march 2012. the deliverable d9.4 âreport on the 1st training workshop on novel mbr technologyâ provides an overview of the presentations given during the workshop.  
â¢ organisation of the second training workshop on âfunctionalized membranes for wastewater treatment - nanoparticles and surface modificationsâ which took place in may 15-17th, 2013 in cetraro, italy.   
â¢ organisation of exploitation seminars in order to determine the potential exploitable results developed within bionexgen and clarify some aspects concerning the ownership and the use of these results  
â¢ updates on patents search   
â¢ to continue the dissemination activities through the website, the newsletters, the participations to conferences and the networking activities.  
  
wp10:  
â¢ smooth and effective collaboration within the consortium  
â¢ delivery of deliverables and milestones in time  
â¢ high quality of the project results  
â¢ tracking and effective mitigation of risks  
â¢ anticipation unexpected developments or new opportunities  
  
wp11:  
â¢ to ensure that all the administrative documents (grant agreement and the consortium agreement) were understood and signed by all the partners.  
â¢ to distribute the pre-financing among the partners and  
â¢ to remind the partnersâ role, level of involvement in the project and the budget planned for their participation in bionexgen.  
â¢ to choose and the set-up of the management platform.  
â¢ to provide assistance to the partners on administrative and financial aspects  
â¢ to get the partners acquainted with the reporting process  
â¢ to perform the first periodic reporting in accordance with the criteria defined by the ec.  
â¢ to ensure that all the administrative and financial documents (form cs) were understood, signed by all the partners and delivered on time to the ec for the first periodic reporting  
â¢ to maintain updated the management platform  
â¢ to solve the issues concerning the syrian partner abu  
â¢ to prepare the amendment  
  
project results:  
resuls obtained within period m1-m12  
  
during the reporting period starting from the 01.09.2010 - 31.08.2011, wp1 through wp5 and wp9 through wp11 have been started.  
   
within wp1 benchmarking data were obtained with the existing mbr membrane from mn by testing industrial wastewater (olive mill, textile, and cosmetics). small scale mbr pilot trials have been successfully started in the laboratories of the partners abu, cbs and cmrdi using practical wastewater from olive mill, cosmetics and textile industry. in parallel, hska has started small pilots using model olive mill wastewater and practical wastewater for which the findings can be compared with the results of abu. the results are summarized in a report (d1.2). in addition laboratory experiments with model foulants (humic acid, proteins and alginate) were conducted using a flat sheet membrane cell. the mbr market in europe and the mena countries has been studied by performing a swot analysis. for this analysis, a specific questionnaire has been developed for collecting the data among bionexgen partners. the results are summarized in the deliverable d1.1. the potential membrane and module materials, as well as the potential membrane manufacturing processes of the bionexgen membranes have been defined additionally an initial cost estimate for novel materials involved has been made in cooperation with cnr-itm and forth. the results are summarized in the deliverables (d1.4 and d1.5). the health and safety aspects have been studied based on a matrix based risk analysis including all potential chemicals for manufacturing the novel membranes. the deliverable d1.6 highlights the findings. deviation: the report on short-term results (d1.2) has been finalized only in month 12 instead of month 6 as initially planned but this does not affect the further progress of the work. no other deviation from the workplan occurred and the respective deliverables have been issued.  
   
wp2 addressed theoretical aspects through computer modelling. forth and cnr-itm were responsible for the tasks under this work package and were supported by hska and ntx. within the overall aim of the wp2 investigation of structures-properties relationships, necessary in the development and design of innovative materials, the main progress is the subdivision of pollutants (textile, olive mill, cosmetics) into three groups as function of the ratio between the cross sections of the cnts and those of pollutants. by analysing the ratios between the cross sections, it is possible to conclude that cnts with diameters less than 3 nm can work as molecular sieves for medium (ii group) and large (i group) sized solutes since the cross sectional ratios are smaller than 1. the calculations indicate that the existing cnts with diameter larger than 3 nm cannot be used as molecular sieves to separate the larger part of the considered pollutants. nevertheless, dynamic effects could cause deviations from this prediction. this is important since it allowed defining a computational strategy for the subsequent simulations aiming at calculation of the rejection of organic solutes of small size (iii group) by the cnts of ntx with diameter smaller the 3 nm. in fact, efficient solutes rejection could be driven by an unfavourable trapping of these molecules in the considered cnts. for example the tyrosol shows an unfavourable electronic free energy when embedded in a cnt with diameters of 1.66 nm. multi-scale simulations (qc and mc) have been planned for the next six months to explore this possibility in advance. this wp has started earlier than planned in the dow and the deliverable d2.1 has been submitted at m12.  
  
within wp3, forth has started to experiment the formation of vertically aligned cnts in the existing commercial mn membrane as well as in a custom-made track-etched membrane through filtering. the active layer of the mn membrane consists of pes with an average pore size of 50 nm. experiments have been performed by using the less expensive cnts which are the mwcnts with an external diameter of around 40 nm. the incorporation of cnts has been attempted by using an improved common filtration system. the incorporation of the cnts in the pores of both membranes has been monitored by sem images of the membrane surface and cross-section as well. the consequent next steps will be to test water permeability and retention efficiency in a small test cell and in addition to improve and optimize the infiltration process. in addition initial experiments on functionalization of the mwcnts by hydroxyl groups have been started. moreover, decorated mwcnts with polymers such as pmma and pgma have been also prepared. this wp has started earlier than planned in the dow.  
   
the main work of wp4 has been done on the preparation of âlooseâ hydrophilic nanofiltration membranes with tailored pore size. two different types of nf membranes have been produced made of 1) polyvinyl alcohol (pva) and 2) polymerisable bicontinuous microemulsion (pbm). the pva membranes prepared so far proofed to be too âdenseâ to be applied over mn membranes (this has been observed by performing water permeability tests). therefore two different approaches (addition of additives, low quantity of polymer in solution) will be studied in detail within the next 6 months. the symmetric pbm membranes have been produced using two different types of surfactants. the first one has been newly synthesized (together with the subcontracting, unical) and the other one is commercially available (sds type). both types of membranes have been successfully made on lab scale using uv and redox initiators. furthermore, the pbm membranes have been successfully coated on commercial mn membranes and their preliminary characterisation tests have supported their great potentialities and validated that the coating has been well performed. further characterisation tests are now in progress to verify the interconnectivity of the pores of the respective membranes. however, the membranes need to be further optimised also for being applied in mbrs. this wp has started earlier than planned in the dow.  
  
within wp5 initial experiments were started to prepare antimicrobial nanoparticles such as agcl/tio2 and chitosan which can be incorporated into nanofilms through pbm or pva techniques (see wp4). the initial syntheses of these two nanoparticles have been conducted. sol-gel synthesized ag/tio2 materials and chitosan nanoparticles were found to be antimicrobial against e.coli. the existing mn mbr membrane was modified by layer-by-layer (lbl) technique by alternating layers of chitosan and layers of alginates. the water flux and rejection for a model foulant (such as humic acid) were measured by hska. the water flux measured in the first samples was too low for expecting an application in mbrs. however, the process has been modified and further experiments will be carried within the next 6 months. this wp has started earlier than planned in the dow.  
   
wp9 supported dissemination, exploitation and training activities. the main objectives of this period were the development of the dissemination tools (projectâs website and brochure) as well as an analysis of the intellectual property mechanisms suitable for the dissemination and the exploitation of bionexgen outcomes. a corporate identity has been developed with the help of a professional communication agency. from this collaboration, a logo and a slogan have been created. in january 2011, the website has been finally opened to the public under the following address: http://www.bionexgen.eu the brochure is available in english since april 2011 and in arabic, greek, turkish, italian and german since august 2011. several partners have started to communicate on the project through participation to conferences and press releases. furthermore, the first issue of the bionexgen newsletter has been released in august 2011. this newsletter can be downloaded on bionexgen website.  
finally, a first report on the ip mechanisms, trademarks and patent survey has been worked out. the results obtained during this study are presented in the deliverable d9.7 submitted to the ec in august 2011. some deviations have occurred in this wp but they are not affecting the progress of the project.  
   
wp10 is related to scientific and technical coordination. the organization of the kick-off meeting in karlsruhe 7-8th november 2010 has been done in collaboration between hska and sez. after that, monthly telephone conferences have been launched. this has created a high team spirit among the partners allowing a smooth and efficient collaboration among them. the second partner meeting has been held in patras, greece and hosted by our partner forth. this meeting has been the occasion to present the first technical progresses of the project. the first interim progress report (deliverable d10.1) has been submitted in may 2011.  
deviation: the kick-off meeting was originally planned 4-5th october 2010. however due to the uncertainty to be able to effectively start the project in september 2010, hska and sez have decided, at the end of august 2010, to postpone the kick-off meeting to 8-9th november.   
  
wp11 is related to project management. sez was responsible for this wp. the first action within this workpackage was to ensure that all administrative documents were understood and signed by all partners. then a scenario concerning the budget distribution among the partners and through the complete duration of the project has been elaborated. furthermore, each partner has been reminded on his role and level of involvement in the project as well as on the budget planned for his participation in bionexgen. the first payment to the partners was slightly delayed and has been mainly released in november 2010 due to the time needed to decide which payment plan was the most suitable for the project and also due to the time necessary to obtain official bank data from the partners. the money transfer to abu in syria could not yet be accomplished since hska administration came to know that the bank of abu is on the black list. hska administration is working on this issue to get the problem settled. another objective of this wp was the set-up of the financial management platform. the german company emdesk has been selected for their very competitive offer and the quality of the interface for the management. the programming of emdesk platform has been finalised in december 2010. to set up the platform, the data have been retrieved from the annex i and the grant preparation forms. from january 2011, the bionexgen partners have been granted by an access to emdesk. in march 2011, an internal budget reporting has been realised among bionexgen partners. the costs spent by each partner have been analysed in order to evaluate if there was no major financial deviation occurring. each partner has been contacted individually in order to clarify which are the costs that can be declared and in some cases to define some correctives actions. in april 2011, the second payment has been released. however, the coordinator was still unable to transfer the two first payments to the syrian partner abu.  
  
resuls obtained within period m13-m30  
  
during the reporting period starting from the 01.09.2011 - 28.02.2013, wp1 through wp7 and wp9 through wp11 have been continued.  
   
within wp1 benchmarking data were obtained with the existing mbr membrane from mn by testing industrial wastewater (textile and olive mill wastewater) and model textile dye wastewater (mtdw). small scale mbr pilot trials have been successfully pursued in the laboratories of the partners cbs and cmrdi using practical wastewater from textile and olive mill industry. in parallel, hska has continued small pilots using model textile dye wastewater. in addition laboratory experiments with model foulants (humic acid and alginate) were conducted using a flat sheet membrane cell. the water permeability and rejection with selected model compounds were also tested. a potential membrane manufacturing process of the bionexgen pbm membranes has been designed. additionally a cost estimate for the novel pbm material and cnts has been made in cooperation with itm-cnr and forth. deviation: pilot trial with olive mill wastewater have been done by cbs since abu left the bionexgen consortium due to political turmoil.  
   
wp2 addressed theoretical aspects through computer modelling. itm-cnr and forth were responsible for the tasks under this work package. the subdivision of pollutants into three groups according to their effective diameters has been made. however, in the last period, the solutes rejection has been analyzed on the basis of another molecular descriptor that is: the minimum! cross-section! projection of the solute atoms on the opening of cnts. in fact, in this way, it is possible to obtain more indicative information regarding the rejection ability of cnts by âsize exclusionâ. according to solute minimum! cross-section! a new classification has been performed. in order to investigate the possibility of having rejection through a mechanism different from size exclusion, the evaluation of the trapping energy of the solutes in the cnt with diameter equal to 1.66 nm is also carried out. efficient solutes rejection could be driven by an unfavourable trapping energy (activated diffusion process) although the aforementioned analysis on the solute sizes gives a different response. multi-scale simulations (qc and mc) have been planned for the next six months to explore this possibility. however it has been shown that for cnts with diameter of 1.66 and molecules like tyrosol this is not the case. calculations of the water flow rate as function of cnt diameters have been also carried out in this period by itm-cnr to predict the number of mwcnts to be used in the porous mn membranes in order to improve the total water flow. various parameters such as the mwcnts length and internal and external diameter were considered in this computational analysis. quantum mechanics calculations about the adsorption of antimicrobial particles on the active layers by means of ctab, dtab and auteab surfactants have been carried out. these calculations concern the activity of the task 2.2. concerning the activity of the task 2.1b, nano-scale sorption of water molecules inside smooth single wall carbon nanotubes (swcnts) with different diameters has been simulated using a grand canonical monte carlo (gcmc). armchair (n,n) swcnts with tube diameter of 8.14, 10.86, 13.58, 16.28 and 27.14 (ã), respectively, with lengths equal to 40 (ã), have been used in this work. after thermodynamic equilibration has been reached, the water molecular structure and organization inside the cnt is examined as a function of cnt diameter. hence, the ordering of the water molecules inside the cnts was examined as a function of cnt diameters. moreover, in this period, nano-scale sorption of small model molecules such as tyrosol, vanillic and p-coumaric acid inside swcnts with the aforementioned diameters has been simulated. the solute molecular structure and organization inside the cnt is examined as a function of cnt diameter, in addition to the ordering of the solute molecules inside these cnts. the main objectives of task 2.1c include: calculation of water (or ethanol) permeability and flow features / characteristics in the interior of composite membranes; simulation of motion of cnts as they approach the polymer matrix. the objective of the task 2.3 is the 3d representation of the aforementioned active layers. active layer reconstruction stages initially included imaging techniques for retrieving 2d data of the material. sems of the active layer prepared by bi-continuous micro emulsion at several resolution levels were received from itm-cnr. image processing was carried out at forth/ice-ht and several geometrical and topological data of the materials, such as the (surface) porosity and the autocorrelation function, were extracted and the milestone ms2 has been submitted at m18.  
   
within wp3, ntx in strong cooperation with forth has developed the optimum protocol for the incorporation of cnts in membranes using the facilities of the company. moreover, the effect of this process on the functional groups of cnts was studied and the results showed that there is no effect on the amount of functional groups attached to the tube. during the last months, a new protocol for the incorporation of cnts in the membranes has been under development. this new protocol aims at developing an easier and economical way for the large scale production of the new enhanced membranes with cnts. the incorporation of cnts into up150t microdyn-nadir membranes has been attempted with the help of simple or dead-end filtration system. different attempts have been performed. basically, the protocol is the following: the infiltration of cnts is carried out through the pet side, and below, the water flow rate is measured through the active pes side of the membrane in a dead-end filtration system. however, infiltration of cnts has been also carried out through pes side. the infiltration of the cnts is achieved in combination with tip sonication.  
during this period, forth has focused their experiments on mwcnts, thin-mwcnts, thin-mwcnt-oh and thin-mwcnt-cooh all provided by ntx, but also on swcnts and dwcnts purchased from cheap tubes (usa). substitution of the carboxylic acid groups (-cooh) with carboxyl anion groups (-coo-) where further prepared and infiltrated. the embedment of cnts into the porous membrane was performed either from the support layer or directly to the thin selective layer. study of dispersion of cnts in suspensions has been achieved. cnt functionalized with deprotonation of carboxy groups (-coo-) present improved dispersion of cnts in water facilitating the incorporation of cnts in the mn membrane. the incorporation of cnts to the membranes has been substantiated with the help of sem images as well as with afm images.  
the best results with respect to water flow have been obtained with the membranes infiltrated with dwcnt and swcnt through pes side and with the membranes infiltrated with thin-mwcnt-cooh through pet side. in these cases the membrane rejection was was probed for model textile dye waste, composed principally by acid red (380 dalton) and remazol brilliant blue r (630 dalton), and reactive black (990 dalton). since the up150 microdyn-nadir membrane belongs to the category of ultrafiltration membranes with a molecular weight cut off, mwco, 150 kdalton and the model foulants used for the retention measurements present a mwco of 1000 dalton at most, that means they need a nanofiltration membrane to be retained, the retention ability improvement due to the incorporation of cnts into the up150 mn membrane will be progressively examined using polyethylene glycol (peg) model compounds of different molecular weights between the two above mentioned mwcos.  
  
moreover, a thin film of polyethersulfone/cnt blend has been coated on existing commercial nadir? microfiltration polymer membranes and water flux and mwco will be also tested. polyethersulfone/ cnt blend membrane can be produce from polyethersulfone/solvent/no solvent system by the immersion phase inversion process in water bath.   
ntx has produced ctns functionalized with a carboxy (-cooh) group. these functionalised cnts were delivered to forth either for the incorporation in the membranes, or for further functionalization. the mwcnts with 97% purity were functionalized with the protocol of ntx and the result led to 5% over the nanotubes weight of functional groups, while the thin-mwcnts were functionalized with two different protocols achieving percentages of functional groups of 7 and 12% respectively. 2 grams of each of these materials were delivered to forth for further experiments.   
ntx has also participated to the realization of cytotoxicity experiments, by developing the protocol for the dispersion of cnts in pf127. for the development of this protocol several parameters were studied, while the facilities of the company were used. in our experiments, its toxicity was evaluated as internal control of the assay. in all of our experiments, we observed a cell viability of 80-90% with the 1% pf-127 which is the internal control of the assay and the effect of cnts on cell viability is compared with pf-127 treated cells. the experiments are conducted at human lung fibroblasts. the toxicity of the compounds was evaluated in terms of cell viability and hemolytic potential of cnts of interest. we assayed a range of concentrations of 0,125âµg/ml to 25âµg/ml for all synthesized cnts. pristine mwcnts revealed a dose-dependent effect on the toxicity with the ranging from 50-70% cell viability, while swcnts and dwcnts, according also to the literature exhibited higher toxicity compared with mwcnts. mwcnts-oh maintain high viability even at high concentrations (50% cell viability at the highest concentration) compared to pristine. a similar pattern is also exhibited by âcooh functionalized. functionalization with water soluble polymer pssna also results in maintenance of high viability compared to pristine mwcts.  
non-covalent interactions of phosphonium and ammonium groups with ssna-functionalized cnts lead to high toxicity profile at concentrations higher than 2,5âµg/ml and 25âµg/ml, respectively. the high antimicrobial activity of phosphonium groups is also depicted with high cytotoxicity profile. it is worth noticing that in lower concentrations tested the cell viability reaches the levels of the internal control of the assay. the covalent attachment of vinylic monomers onto phenol-functionalized cnts exhibits no statistical significant changes in cell viability in the concentrations tested from 5 to 0,125âµg/ml for thin-mwcnts, whereas further introduction to vinylic monomers of the cytotoxic ammonium groups resulted in a balanced toxicity profile. the range of concentrations used in the cell proliferation assays did not exhibit any hemolytic activity nor the high concentrations tested (50âµg/ml & 100âµg/ml) for incubation intervals of 30min, 1, 2 and 3 h. the antimicrobial properties of polymer modified carbon nanotubes were also assayed in a range of bacterial populations. it seems that there is a different effect depending on the type of bacteria (gram positive or negative). however, the dispersion media, used for the toxicity assays, seems not to be optimal for such experiments.  
  
the main work of wp4 has been done on the preparation of âlooseâ hydrophilic nanofiltration membranes with tailored pore size. the synthesis of acryloyloxyundecyltriethyl ammonium bromide (auteab) has still been synthesized following the consolidated route and used as surfactant for polymerisable bicontinuous microemulsion (pbm) preparation. a new commercial surfactant dodecyltrimethylammonium bromide (dtab) was employed for pbm preparation in order to decrease membrane final cost.  
pbm membranes prepared with auteab were used as coating material for pes membranes from microdyn-nadir and sent to the partner hska for rejection tests with fouling model compounds and water permeability tests. some variables, which can affect membrane polymerization procedure, were taken into account and evaluated (e.g. temperature and hema concentration). different antimicrobial agents prepared by iztech, itm-cnr and cmrdi were incorporated into the bicontinuous microemulsion which was polymerised following the traditional procedure used on mn pes membranes. the prepared membranes have been sent to iztech for the evaluation of antimicrobial activity. however pbm membranes themselves showed antimicrobial activity due to the presence of cationic surfactant (auteab or d ...

# SONO

Project Acronym: SONO

programme & topic: FP7-NMP NMP-2008-1.2-1

Most frequent returning words in objectives:

* ('pilot', 51)
* ('process', 50)
* ('line', 33)
* ('design', 32)
* ('sono', 27)
* ('reactor', 27)
* ('control', 25)
* ('application', 24)
* ('nanoparticles', 22)
* ('machine', 21)
* ('textiles', 20)
* ('production', 20)
* ('monitoring', 20)
* ('analysis', 20)
* ('results', 18)
* ('developed', 18)
* ('system', 18)
* ('product', 18)
* ('solution', 17)
* ('products', 17)
* ('characterization', 16)
* ('project', 15)
* ('water', 15)
* ('metrology', 15)

executive summary:  
the idea behind the sono project was an attempt to make the hospital a safer place by replacing all the currently used textiles by antibacterial textiles. it is well-known that approximately 1 million people are dying every year in hospitals around the world out of nosocomial infections.  
sono was based on early results demonstrating that metal oxide (mo) nanoparticles (nps), (zno, cuo, and mgo) sonochemically coated on various fabrics can kill efficiently a large variety of bacteria.  
it was therefore proposed that a step forward towards the goal of eliminating nosocomial bacteria, machines for a roll to roll sonochemical coating will be built and the coated fabrics will be checked for 1) antibacterial properties, 2) mechanical properties 3) leaching into water and saline solution and 4) withstanding long washing cycles at hospital washing machines (75 and 92 0c). these properties were in addition to regular characterization measurements for determining the amount of the nps on the fabric, the size and shape of the nps.  
two roll to roll sonochemically coating machines were built in the course of the project. both have produced a homogeneously nice coating of the mo nps on cotton and polyester and their mixtures. the coated fabrics revealed excellent antibacterial properties. no leaching of nps of mo into water or saline solution is detected over 96 testing hours.  
the coated fabrics were washed 65 cycles at 75 0 c using a ph neutral detergent and were found having a > log 4 killing of a few common bacteria.  
  
unforseen achievement in the course of the project   
a new coating sonochemical technique called "throwing stones" was developed in the course of the project. it resulted from the industrial complain on the use of ethanol in the synthesis of the mo nps. the ethanol was avoided by purchasing mo nps from a commercial source and employing the ultrasonic waves to throw the np onto the fabric.  
the partners have discovered that the mo nps can kill not only sensitive bacteria but also resistant bacteria, i. e. bacteria resistant to antibiotic.  
finally the answer to the question can the hospital become a safer place using the mo nps was given in an experiment carried out in the pigorov hospital in sophia bulgaria in an experiment testing 25 patients in an rooms fully equipped with antibacterial coated nps.   
  
the anwer was yes, the hospital is safer for patients using the sono fabrics.  
it is therefore proposed that the next step should be building an industrial machine answering specific requirements of an end user  
  
project context and objectives:  
description of project context and objectives   
concept  
  
hospital-acquired (nosocomial) infections are a major financial issue in the european healthcare system. the financial impact of these infections counteract medical advances and expensive medical treatments by increasing the length of hospital stay by at least 8 days on average per affected patient, hence adding more than 10 million patient days in hospitals in europe per year. the statistics on patient safety in the eu show alarming tendencies:  
â¢ 1 in 10 patients are affected by hospital-acquired infections   
â¢ 3 million deaths are caused by hospital-acquired infections yearly  
an active infection control program of patients and personnel and hygiene measures, have proven to significantly reduce both the number of infections and hospitalisation costs.   
the sono project directly addresses the above problems by developing a pilot line for the production of medical antibacterial textiles.   
the pilot line will be based on the scale-up of a sonochemical process developed and patented at biu laboratories. the pilot line will use a sonochemical technique to produce and deposit inorganic antimicrobial nanoparticles on medical textiles, e.g. hospital sheets, medical coats and bandages.  
sonicators are used industrially for heavy and light duty cleaning, for water disinfection and for sewage treatment. it is also used in the food industry for emulsification and drying. the proposed concept based on one step sonochemical continuous process to produce nanoparticles and at the same time impregnate them as antibacterial factors on textile is novel in an industrial scale for this application.   
the concept has already been proven and patented on a lab scale where sonochemistry was applied to impregnate nanoparticles in a single-step process.  
it was demonstrated that due to the special properties of the sonochemical method the antibacterial nanoparticles are adsorbed permanently on the fibres even in the course of 70 âlaundry cyclesâ as proven by biu. the sonochemical impregnation process is a one-step procedure in which the nanoparticles are simultaneously created in solution and applied onto the fabric surface at such a high speed that they either form chemical bonds with the textile substrate, or physically embedded in the fabric in cases where no functional groups are available in the fibre (i.e. polypropylene).  
thus the proposed process has its main advantages in: reducing production time due to the very effective one step process, reduction of fibre damage, increasing the uniformity of distribution of the nanoparticles, lowering product cost (based on mg or zn oxides versus silver for exisiting products) and environmentally friendly because it uses water solution, and there is no leaching of the nanoparticles to the environment.  
  
objectives  
the main objective of this project is to build a pilot line based on a sonochemical reactor to produce biocidal textiles by impregnating antibacterial nanoparticles (e.g. mgo and zno) on the fabrics. the proposed pilot will be based on modeling of sonochemical reactors. the process will be metrological and safety controlled.  
the process will lower product cost (based on mg or zn oxides versus silver for exisiting products and ultrasound reaction â a low cost process); it is safe (no subsequent reversal or loss of zno/mgo to the patient wound) and environmetally friendly using water solution and low amnounts of metal oxides (zn and mg); reduce the production time (one step) ; reduce the fibre damage, efficient ; increase nanporticles distribution uniformity,.  
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1.1 pilot components identification and specification/ design  
1.2 metrology, monitoring and safety devices identification and specification/ design  
1.3 characterization and design of workers and environmental protection  
1.4 product characterization  
2 develop modeling for sonochemical reactors   
2.1 electro-acoustic modeling  
2.2 modeling acoustic waves in bubbly liquid  
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2.5 modelling of transport of chemicals in the reactor  
2.6 modelling of heat transfer in the reactor  
2.7 optimization of the sonochemical reactor  
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4 pilot line components manufacturing and assembly   
4.1 production of the pilot line components   
4.2 assemble the pilot lines, at end usersâ sites  
4.3 analysis of the two pilot lines performance and optimization of one final pilot  
4.4 on-going support of the pilot line operation  
  
5 optimization of the pilot processes (antibacterial activity) and production of the antibacterial textiles  
5.1 optimisation of ultrasonic process parameters and manufacturing of the products accordingly   
5.2 optimization of the textile products with simultaneous sonochemical/enzymatic/nps coating of textiles and manufacturing of the products accordingly.   
5.3 simultaneous hybrid (biopolymer-nps) antimicrobial embedment using us and manufacturing of the products accordingly  
  
6 product characterization and end-user validation  
the main objective here will be to get the highest values for reproducibility, accuracy and precision.  
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6.4 tests the leaching of the nanoparticles from the textile to the environment  
6.5 characterization and production of confection methods and production of pillow covers, bad sheets and pajamas with the antibacterial textiles  
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6.7 conclusions of product validation by the end users  
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7.1 process and product cost effectiveness for the pilot and the up scaled design - lcc  
7.2 life cycle assessment (lca) of product and processes following iso 14040 standards, according to setac proposals  
7.3 evaluation of the impacts of the new products on medical textiles regulations  
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main s&t results/foregrounds   
  
modelling of sonochemical reactors (wit)  
this work package provides tools for optimization of operating regime/conditions for the sonochemical reactor. the main objectives/tasks in this work package are explained below.  
  
2.1: establish the relations between the voltage/current applied to the ultrasonic transducer and the in-fluid acoustic field versus frequency  
the wave propagation on the fluids depends on the us generator âtransducer & resonatorâ dimensions. on the ced us generators, the transducers are connected to the tubular resonators. the resonator deformation shape and the corresponding frequency resonances depend on the length of the resonator. the results have been presented in the deliverable d2.1.  
  
2.2: define the volume of the reactor where conditions for cavitation exist taking into account interaction of bubbles with acoustic field  
a mathematical model to simulate the acoustic wave propagation during the operations of the transducers was developed. the effects of cavitation bubbles were included by introducing a complex wavenumber to the governing helmholtz equation. an in-house code based on the meshless radial basis integral equation method has been developed. a sensitivity analysis was carried out to examine the effects of various parameters on the pressure distribution inside the tank. with the in-house codes, zones where the cavitation threshold is exceeded can be prescribed with the complex-valued wavenumber while zones where the pressure is lower than the cavitation threshold can be prescribed with the real-valued wavenumber. details of the models and results for the acoustic waves in bubbly liquid can be found in the deliverable d2.5 .  
   
2.3: design the mechanical mixing required for efficient operation of the reactor and delivery of the required chemicals to the cavitation zone  
a numerical model for transport of chemicals in the sonochemical reactor has been developed. the model requires as an input the velocity field which is obtained as a result of the flow model. the model for transport of chemicals can be used for analysis of the transport and reactions in the sonochemical tank, and also to design a better mechanical mixing if required. the initial reagent added to the reactor is (zn(oac)2) and as solvent water-ethanol mixture is used. after the temperature reaches 60oc, ammonia solution (nh4oh) is added to the reactor. the zinc hydroxide reacts further with ammonia solution yielding tetra ammonium zinc hydroxide (tazh). details of the models and results for mechanical mixing and transport of chemicals in the reactor can be found in the deliverables d2.2 and d2.3 , respectively.  
2.4: determine the heating requirements and viscosity of the liquid  
a three-dimensional numerical model for the pilot plant designed by ced has been developed. the model is used to simulate the flow and heat transfer inside the tank before and during the operation of the heaters. mechanical mixing is included into the model. it was found that the flow due to buoyancy is comparable or more significant than the flow due to mechanical mixing in the upper part of the reactor. the model was calibrated using temperature measurements in the reactor. details of the model and the results obtained can be found in deliverable d2.4 .  
  
2.5: develop a model for multiple bubble dynamics in order to establish a link between the micro and macro processes/parameters in the reactor  
a 3d numerical model of multiple bubble dynamics was developed based on the boundary element method. with the developed model, parametric study was undertaken analysing the bubble dynamics along a rigid wall. the effects of the following reactor parameters were investigated: wave amplitude and frequency, temperature of the liquid, liquid properties (density, surface tension and ratio of specific heat for vapour of the liquid and gas), initial bubble size and distance from the wall.   
in ethanol, the bubble evolves faster and ends with higher jet speed, temperature and pressure than in water. the influence of ambient temperature on the bubble evolution becomes prominent when it is close to the boiling point of the liquid, yielding a higher jet speed during the bubble collapse. the analysis of effects of surface tension showed negligible when the initial bubble radius r0=10 âµm.   
  
simulations were also carried out on a cluster of bubbles of different sizes containing up to 100 bubbles. the effects of the bubble cluster on the potential field across the solution domain were investigated. the presence of a solid boundary was found to boost the interactions within a bubble cluster. a bubble cluster of different bubble sizes results in more turbulent flow, thereby potentially leading to more noticeable impacts on the solid boundary. more details on the developed models of bubble dynamics and obtained results can be found in deliverables d2.6 and d2.8 .  
  
   
2.6: optimize the operating conditions/parameters in the reactor  
this task utilized the developed models from the previous tasks to the optimization of the acoustic pressure distribution inside bubbly liquid and the mixing and transport in the sonochemical reactors of via and ced. an optimization based on the distance between the fabric and the transducer was performed. the results of the analysis suggest that the distances of 5 and 20mm offer more optimal operating conditions for the reactors of via and ced, respectively, although the accuracy of the results is subject to the accuracy of the assumption for the volume fraction and bubble sizes used. an approach to estimate the attenuation coefficient based on the calorimetric measurements was proposed, which will help with future simulations. the results indicated the possibility of uneven coating due to the nodes of the pressure waves between the left and right transducers almost coinciding with one another.   
simulations for the via reactor showed that the mixing in the zones where sedimentation occurs can be improved by using a 4-inlets, 2-outlets configuration appropriately placed around the walls of the tank. more details on the optimization of the operating conditions in the pilot plants can be found in the deliverable d2.7 .  
   
2.7: design a scale-up for the reactor to a full scale plant  
the scale-up of the prototype reactors developed by via and ced was carried out. it was decided that a direct scale-up of the reactorâs dimensions was not feasible since the other parameters such as pressure, power input and the optimal distance between the fabric and the transducers do not necessarily scale linearly. for the viaâs reactor, two designs based on increasing the number of transducers were created. the first design employed 8 transducers and the contours of the pressure across the fabric appear to suggest non-uniform nanoparticles coating. to overcome this problem, the second design employed 12 transducers and they were placed so that wave nodes and antinodes from the transducers coincide.   
a potential scaled-up design of cedâs reactor was also proposed which showed that a scale up with the current design of the transducers may not be feasible. therefore numerical simulations were performed for the scale-up design of the sonochemical reactor utilizing a new tubular resonators developed by ced and via. trapezoidal reflectors were utilized in order to improve the efficiency. more details can be found in deliverables d8.2 and d8.3.  
  
metrology, online monitoring, and the control system development (afi)  
the sonochemical machine implemented on two pilot lines, includes various process variables, parameters and actions which are required to be controlled by automatic system to ensure the proper conditions for impregnating antibacterial nano-particles into the desired fabric. the control system of the pilot line includes a software application with a dedicated hmi which will provide online display of the monitored process parameters. the hmi application activates manual and automatic control of the pilot line mechanism (pumps, valves, fabric progress). the system displays alerts for values out of valid range, and provides alarms for safety events. the application is based on the pulse scada/hmi software which was developed for supporting the specific requirements of online application to control the 2 pilot line machine assembled during the sono project.   
the system designed includes a programmable logic controller (plc) which controls the various end point devices as inputs/outputs to the main scada/hmi server and the logging database.  
the application is integrated with the offline analysis tool used for evaluating the process operation parameters compared with the quality of the produced fabric (results of wp6), and allow tuning and optimization of the sono process for different production scenarios.   
   
sono online application â process operation display  
during the project the work in wp3 covered the following activities:  
requirements definitions for monitoring and control hmi application, and for the offline process analysis tool, and were based on pilot machine definitions in wp1, which were elaborated in regard to process monitoring, control and automation of the sono machine.  
the requirements definition was summarized in d3.1 - metrology, monitoring, safety and control application and process analysis tool requirements document.  
detailed design of metrology, monitoring and control system â including definition of process control and automation methods for the sono-chemical process, based on metrology and automation equipment installed in the sono machines, in different scenarios of operation.  
the detailed design was formalized in d3.2- detailed design of the metrology, monitoring and control system, which covered the definition of metrology and control devices, the online and offline applications high level design, and detailed design for system modules.  
  
the sono machine operation was defined in three automated processes:  
reagent preparation: filling water and reagent in preparation tank and mixing to dissolve.  
sono tank preparation: filling main tank with ethanol, ammonia and reagent, activating mixing pumps and heating until target temperature is reached.  
sono process activation: activating sonotrodes and fabric motor to start production. adding ammonia and reagent to compensate and maintain concentration.  
  
development of application software for data acquisition, on-line monitoring of sonochemical process parameters and automation of sono machine operation. the application development was performed in several phases, following changes in the machine design and the process automation needs in the two sono pilot machines.  
develop application software for offline analysis and correlation with test results: the offline tool can present comparison of different executions of the us process, as well as test results for the produced fabric . data is taken from the sono machine database, and from the samples characterization database maintained by pr.  
development of plc software for retrieving process parameters and automatic operation of the sono machine components, implemented separately for the two sono machines.  
  
 integration and testing of the control equipment, the plc, and the sono application software: the work included simulation of sensor data and validation of control system performance in the target scenarios. the integration tests were describes in d3.4 - report on lab tests of the developed devices.  
   
offline analysis application â experiment summary screen and graph results screen  
the products of the above development was installed on the sono machines in davo and klo sites, and is currently under further testing and adjustments during last period of sono project. in addition, the development of offline analysis application software will continue to support further experimentation with the sono machine and optimization of the sono process.  
summary of overall achievements:  
â¢ design of the metrology, monitoring and control system for sono machine  
â¢ develop application software for data acquisition and on-line monitoring   
â¢ construct monitoring control and automation system for both sono machines   
â¢ develop automation mechanism for sono process   
â¢ develop application software for offline analysis of test results  
  
pilot components manufacturing and assembly (ced)  
the aim of this work package was to manufacture the sonochemical machine pilot line based on the recommendations and the design achieved on the wp1. the objectives of this work package are given here after.  
â¢ producing the pilot line components  
â¢ assemble the pilot lines, at end usersâ sites  
â¢ analysis of the two pilot lines performance and optimization of one final pilot  
â¢ on gong support of the pilot line operation  
  
the functional schema of the chemical process as defined in the d1.1 is given here after. the numbers of tank requested for the chemical process are:  
â¢ the reagent tank: the chemical preparation before sonochemistry process.  
â¢ the sonochemical tank: the ultrasonic transducers are installed in this tank to generate the cavitations.  
â¢ the squeezing roller wasted: the chemical solution is collected after squeezing process.   
â¢ the ethanol recovery tank: the wasted ethanol vapor is collected in this tank.  
  
 the textile is unfolded on the sonochemical tank for coating process. the textile is unrolled near the ultrasonic transducer (tubular transducer for the ced machine and flat transducer for via machine). a drying machine is added at the end of the pilot line.  
   
the machine has been manufactured and assembled at the ced facilities. the connection and the cabling of the whole machine have been done also at the ced facilities.   
 the list of sensors has been defined by chemists needed to control the chemical process. the automatic valves have been installed between the tanks for full automation control of the machine. the connection between all subsystems of the machine is presented here after.  
   
both pilot lines have been manufactured and are fully controlled   
both pilot lines (ced / via) were tested in three levels, component, subsystem and coupling configuration   
the first test show (visually) the cavitation generation in the both pilotsâ line  
the unfolding textile sub system has been tested on speed range as defined in the d1.1  
the heating subsystem on the ced pilot line have been check  
the ultrasound and unfolding subsystems have been tested on the work temperature (70 â°c)  
the washing and drying machine works at 1m/min textile speed.   
  
sono â coating chemical process and mechanism  
the metal oxides nanoparticles were generated using an established working solution consisting of a metal ammonia complex in ethyl alcohol â water solution.   
to prepare metal oxides (meo) nanoparticles by means of ultrasound the starting reagents are: zinc acetate dihydrate: (zn(oac)2\*2h2o) and copper acetate monohydrate: cu(oac)2\*h2o and ammonia solution (nh4oh). water â ethanol (1:9 v/v) mixture is used as solvent.   
the chemical reactions are:  
zn(oac)2 + 2nh4oh = zn(oh)2 + 2nh4oac (1)  
zn(oh)2 + 4nh4oh ? [zn(nh3)4] (oh)2 + 4h2o (2)  
cu(oac)2 + 2nh4oh = cu(oh)2 + 2nh4oac (3)   
cu(oh)2 + 4nh4oh + 2 h2o ? [cu(nh3)4(h2o)2]2+ 2(ho-) (4)   
the metal ammonia complexes are water soluble. when ethanol is added the solubility of complex in water â ethanol solution is still high. (a translucent solution of zinc complex in water â ethanol is more accurate description).   
when the ultrasonic transducers are on, the presence of an acoustic field generates cavitation bubbles. after several acoustic phases the bubbles collapse symmetrically in a homogenous media. according to the hot spot theory, the temperature and pressure developed locally could reach 5,000âºk and up to 2,000 atmospheres. these extreme conditions decompose the zinc or copper complexes found in the surrounding layer of cavitation bubble by extruding the ammonia ligand from the complex structure leading, initially, to zinc or copper hydroxides while the collapsing bubbles are generating nano sized metal oxides:  
   
[zn(nh3)4] (oh)2 + 4h2o ? zn(oh)2 + 4nh4oh (5 ...

# TAGS

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programme & topic: FP7-NMP NMP.2011.2.3-3

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work in the coming period will focus on the area of therapy, and it is hoped that the work performed and outcomes will be as successful as the previous periods.   
  
potential impact:  
at the level of end-users  
â¢ the project will offer a platform for end-users to convey their desires and requirements.  
â¢ end-users will obtain direct information on the state-of-art in the development of new products, their opportunities and risks.   
â¢ awareness about needs of the elderly, who represent a big share of eu people, will increase among the scientific community and manufacturers.  
â¢ demands of end-users on textiles will be recognized and psychological preventing innovation will be overcome.  
â¢ there will be significant contribution to the improvement of the quality of lives for the elderly and also of the working practices of the care-givers.  
â¢ care-givers will gain better understanding of materials they use which will lead to their improved competence in given field.  
â¢ effective protection and health care for europeâs citizens will improve.  
  
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â¢ industry will benefit from access to scientific experts, graduates and technicians, state-of-the art, research and development facilities in academia.  
â¢ exploiting of new materials will help to develop new products based on the requirements of ageing people, overcoming of european paradox.  
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â¢ opportunities will be created to develop with end-users a mutually understandable set of definitions and specifications of quality and performance.  
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â¢ they will be recognized as experts in the field of materials and products for an ageing society.  
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10. dcs - democentersipe - italy - sme - innovation and technology transfer organisation  
  
project results:  
work performed to date has comprised the elicitation of information about the functionality, comfort, safety, and convenience of clothing and textiles for the elderly, this has been achieved in a number of ways. literature searches have allowed a broad review of existing and emerging technology, and full analysis of sales and market opportunities. questionnaires and semi-formal structured interviews with care home staff, relatives, and end users have provided a comprehensive overview of the everyday problems faced by older individuals, and the benefits and short comings of current products in use, and in some cases, highlighted the need and opportunities for new innovations.  
  
project meetings have been held regularly and have been attended by all consortium members, and invited experts. this has served to overcome barriers, and build true multidisciplinary teams equipped to build new research teams and further develop ideas. at each meeting industrial visits have been performed to educate consortium members on areas and issues previously unknown to them, which has been instrumental in the brainstorming sessions in shaping new project ideas.   
  
ideas generated in brainstorming sessions have been further developed, and many new projects have started as a result of the tags project meetings and consortium members. additionally, more are being worked into new funding proposals to try and develop products to improve the everyday lives of the ageing population.   
  
to date, the areas of bedding, clothing, and hygiene have been addressed, with clothing and hygiene being focused on in period two, preparation has begun for the focus of therapy in the third and final period.  
   
it has been clear throughout the research that despite textiles paying a daily and necessary role in the lives of older people, from clothing and bedding, to hygiene and incontinence products, that the two are rarely considered together and so innovation in the area is fairly stagnant. research has shown that new products are required by individuals and care givers, and input by manufacturers has provided a multitude of new materials and manufacturing capabilities that could allow these advances.   
  
as a direct results of tags, the following projects have been initiated.   
â¢ vesta â linea vesta is a clothing brand which specialises in the production of adaptive clothing specifically designed to be functional regarding the dressing and undressing needs, while enhancing and encouraging design and dignity. the clothes are specifically aimed at individuals with loss of autonomy from stroke, dementia, or other age related condition. the company was established as a result of partners meeting at a tags consortium meeting, and realising that collectively, they had the necessary skills and resources, and the need for clothing such as this being confirmed.   
â¢ news project - the aim of the news project is to develop washable textile sensors for the detection of bed moisture. these washable sensors, will use rfid technology to alert care givers, so that appropriate action can be taken upon the initial detection of moisture. this project was initiated following the meeting of project partners at a tags consortium meeting.  
â¢ horizon 2020 application â an application has been written and submitted to the horizon 2020 funding scheme. the project team is partly made up of members from the tags consortium.   
  
work in the coming period will focus on the area of therapy, and it is hoped that the work performed and outcomes will be as successful as the previous periods.   
  
potential impact:  
at the level of end-users  
â¢ the project will offer a platform for end-users to convey their desires and requirements.  
â¢ end-users will obtain direct information on the state-of-art in the development of new products, their opportunities and risks.   
â¢ awareness about needs of the elderly, who represent a big share of eu people, will increase among the scientific community and manufacturers.  
â¢ demands of end-users on textiles will be recognized and psychological preventing innovation will be overcome.  
â¢ there will be significant contribution to the improvement of the quality of lives for the elderly and also of the working practices of the care-givers.  
â¢ care-givers will gain better understanding of materials they use which will lead to their improved competence in given field.  
â¢ effective protection and health care for europeâs citizens will improve.  
  
at the level of industry   
â¢ industry will benefit from access to scientific experts, graduates and technicians, state-of-the art, research and development facilities in academia.  
â¢ exploiting of new materials will help to develop new products based on the requirements of ageing people, overcoming of european paradox.  
â¢ manufacturers will have direct access to the requirements of end-users.  
â¢ opportunities will be created to develop with end-users a mutually understandable set of definitions and specifications of quality and performance.  
â¢ initiation of joint activities will lead to new competitive products and will open new markets for the industry.  
â¢ new areas of textile application will open.  
â¢ by offering solutions, the ability of european enterprises to compete in the global marketplace will foster.   
â¢ establishment of new contacts and co-operations, strengthening of exiting innovation networks will be supported.  
â¢ technology sharing and licensing will be promoted.  
â¢ project web page will act as a source of information from experts in the field of textiles and clothing for ageing people and supply european researchers, manufacturers, and policy makers with easily accessible information on new materials for application in textiles for the elderly.  
â¢ new business opportunities will be promoted through sharing of knowledge not only between industrial, research and end-user sector, but also between eu member states.  
  
at the level of research and technology transfer institutions  
â¢ they will be recognized as experts in the field of materials and products for an ageing society.  
â¢ improved access to the development and marketing concept, and business information.  
â¢ better identification of socio-economic imperatives to guide research.   
â¢ development of new research activities.  
â¢ establishment of the stable network between partners, fostering mutual trust, strengthening of their competence in a given field.  
â¢ increase attractiveness of universities for industrial collaborations.  
â¢ weaker borders between academia and industry.  
  
at the european level   
â¢ the activity of the project will boost development in the field of products for ageing society. skills and creativity of europe will become broader.  
â¢ the consortium will demonstrate examples of active cooperation which will initiate other institutions to follow.  
â¢ active work in the field of textiles for an ageing society will demonstrate the capability of european countries to enhance quality of european citizens.  
â¢ initiation of new product development and product design will strengthen european industrial competitiveness.  
  
list of websites:  
http://www.textilesforageingsociety.eu/

# T-POT

Project Acronym: T-POT

programme & topic: FP7-REGPOT REGPOT-2008-1-01

Most frequent returning words in objectives:

* ('research', 64)
* ('textile', 52)
* ('university', 32)
* ('prof.', 25)
* ('project', 24)
* ('equipment', 23)
* ('stfi', 20)
* ('croatian', 18)
* ('leitat', 18)
* ('empa', 18)
* ('workshop', 18)
* ('technology', 16)
* ('science', 15)
* ('researchers', 15)
* ('textiles', 15)
* ('t-pot', 14)
* ('zagreb', 14)
* ('laboratories', 14)
* ('held', 13)
* ('group', 13)
* ('faculty', 12)
* ('months', 12)
* ('transfer', 12)
* ('visit', 12)

executive summary:  
unlocking the croatian textile research potentials  
grant agreement 229801  
  
t-pot aims to reinforce research potentials of the faculty of textile technology of the university of zagreb (ttf) in order to strengthen the university sector to become one of the components of the national innovation system in croatia. the goals are to develop the capacity for breakthrough research, leading to innovative textile and textile related products, contributing in this way to the local industry, both nationally and in the region.   
  
the overall objective of t-pot is to unlock and upgrade the research potential of the faculty of textile technology (ttf), particularly its textile science research centre, enabling enhanced participation of croatian textile organisations in research activities at the european level, in order to support the harmonisation and integration process of croatian textile entities into the european research area.   
  
the reinforcement of ttf's research potentials is done through the reinforcement of human and material potential, as well as the research infrastructure. the recently established textile science research centre is upgraded to become one of the components of the national innovation. top scientists are attracted to the country for exchange of know-how and guidance of croatian textile manufacturers. that is why t-pot addresses all major issues of improvement of research capacities, addressed in fp7 capacities work programme: research potential, as topics for regpot-2008-1:  
  
1. reinforcement of s&t potential  
2. developing strategic partnerships with well established research groups  
3. supporting and mobilising the human & material resources  
4. facilitating communication between the centres having similar scientific interest  
5. disseminating scientific information and research results  
6. improving the responses to socio-economic needs (of croatia).  
  
project context and objectives:  
all objectives envisaged to be carried out during the project lifetime have been successfully completed and all tasks have been concluded. wp1: management t.1.1 organisation of periodical meetings - meetings of the management board (kick-off, progress meetings every 6 months) - meetings of the management team (progress meetings once per month) t.1.2 contract administration t.1.3 financial administration t.1.4 project reporting (midterm and final reports) the management team performed all envisaged tasks timely and in accordance with the best practices. effective project management procedures were detailed in project handbook (d.1.1). operational board meet on a regular monthly basis to discuss current project issues and manage possible changes while management board held regular 6 months based meetings. the quality assurance was controlled by constant monitoring of execution, reaching of milestones as well as producing of deliverables on time. wp2: developing strategic partnerships for know-how transfer t.2.1 initiating partnerships: with 3 institutes (stfi, leitat and infmp) and 1 sme (gze). additional partnership with empa and university of ljubljana.   
t.2.2 phd employment and secondments: employment of 3 young scientists. total secondments duration: 16 months. - marina turalija, 01.09.2009.-01.05.2010.; 01.07.2010.-01.08.2010.; 10.03.2011.-20.05.2011., empa, st. gallen, switzerland (13 montths) - eva magovac, 19.11.2010.-19.12.2010, university of ljubljana, slovenia (1 month) - zorana kovacevic, 18.10.2010.-18.12.2010., institute of natural fibers and medicinal plants (infmp), poznan, poland (2 months) t.2.3 mentors know-how transfer (visit of mentor to empa, infmp and university of ljubljana) - sandra bischof vukusic: -16.11.-20.11.2009, empa, department for advanced fibers, st. gallen, switzerland - 15 till 17 june 2010, infmp - november 2010, university of ljubljana, ljubljana, slovenia t-2.4 research secondments, up to 6 months within eu borders. total secondments duration: 4 months. - sanja ercegovic razic, from 16.06.2009.- 20.07.2009, leitat, terassa, spain (1 month) - antoneta tomljenovic, from 28.02.2011.-18.03.2011, leitat, terassa, spain (1 month) - vedran durasevic, from 01.01.2011.-03.04.2011, university of leeds, colour science department, leeds, uk (2 months) t.2.5 research secondments, up to 2 weeks: croatian scientists: - sandra bischof vukusic, 7.03.-27.03.2009, the university of georgia, textile sciences, dawson hall, athens, ga, usa (2 weeks) - tihana miksa perkovic, 31.01.2010 â 06.02.2010, gze, italy (1 week) - martinia ira glogar, 28.08.2011-03.09.2011, gze, italy, (1 week) eu scientists: - dr. thomas pfueller, 15.05.2011.-21.05.2011, stfi, chemnitz, germany (1 week) - edyta bogacz, 06.06.2011.-17.06.2011, infmp, poznan, poland (2 weeks) - moises moron soler, 18.02.2011.-26.02.2011, leitat, terassa, spain (1 week) t.2.6 hosting scientists - prof. charles q. yang, 27.10.2011-3.11.2011, university of georgia, ga, usa - dr. sabyaschi gaan, 17-19.10.2011, empa, switzerland - prof. david hui, 5.5.2012-12.5.2012, university of new orleans, usa. wp3: recruitment of experienced researchers (for know-how transfer and setting up of new research group t.3.3 employment of dr. andrea katovic, university of calabria, italy, in two shifts: - first shift 1.10.2009-1.3.2010 (5 months) - second shift 1.10.2010.-1.5.2011 (7 months). wp4: acquisition and upgrading of research equipment and setting up new laboratories t.4.1-t.4.4 acquisition of equipment (tga, dsc, ftir, sem) t.4.5 presentation of new laboratories at the following occasions: - opening ceremony: 25.02.2010. - workshop held by prof. charles q. yang on 2nd november 2011. - 19th annul conference of croatian microscopy society, held on 2nd december 2011. wp5: organisation of workshops and conferences t.5.1 training at partners premises â 3 in house 3-day trainings at leitat, stfi and inmfp. additional workshop was held at gze. - leitat (terrassa, spain) from 16 till 19 june 2009 - stfi (chemnitz, germany) from 29 november till 4 december 2009 - gze (montelupo, italy) from 27th-28th may 2010. - infmp (poznan, poland) from 15 till 17 june 2010. t.5.2 training organized by ttf in croatia - 2 worshops: - croatian chamber of economy (hgk): innovation, 21-23.09.2009. - croatian chamber of trades and crafts (hok): innovation management, 9 -11.05.2011. t.5.3 itc&dc 2010 conference â participation of all partnering institutions. - 3-6.10.2010. dubrovnik, croatia t.5.4 textile science & economy 2010 symposium, 16.01.2010. zagreb, croatia. - organisation of symposuim jointly with croatian chamber of commerce and croatian employer's organisation. participation of all partnering institutions at the round table. t.5.5 attendance at textile and related conferences: - aatcc, itc&dc, ts&e, tbis, autex attendence on numerous workshops. t.5.6 dissemination conference held in coordination with croatian chamber of trades and crafts, 16.02.2012. wp6: dissemination t 6.1 textile portal, http://www.ts-rc.eu/ t 6.2 t-pot project web site: http://www.t-pot.eu/ t.6.3 step web site, http://www.ttf.unizg.hr/step/about.htm t.6.4 postgraduate seminars, publication of book of scientific papers of young researchers: young scientists in protective textiles research (ed. s. bischof vukusic, d. katovic), 2011. t.6.5 textile forums: - ken greeson, cotton opportunities, cotton incorporated, nc, usa - ljubica cesnik, safety & protection, du pont international, slovenia - dinka liplin-prpic, power of innovation, schoeller textiles, switzerland t 6.6 presentations (tv, radio, annual conference etc.) - scientific knowledge, hrt 1 - 18.02.2012. obrtnik & partner (craftmen & partner), tv: hrt1 t.6.7 printing and publishing (brochures, flyers, promo materials, conference proceedings etc.). flyers: t-pot, tsrc, scientific tsrc laboratories books: ? young scientists in protective textiles research - functional protective textiles - t-pot monography conference proceedings: textile science & economy 2010   
  
project results:  
main s&t results wp2 â strategic partnerships and know-how transfer the main purpose of the wp2 is to develop strategic or twinning partnerships with related textile institutions. there are 3 objectives of wp2: - formation of strategic partnerships focused on capacity building through know-how transfer - sharing of research resources - joint initiatives for developing services in support of business and innovation t 2.1. initiating partnerships the aim of this task was to initiate new strategic partnerships with at least 3 but possibly more partnering institutions, in order to speed up integration of ttf and trsc into era and broaden the knowledge base of ttf and entire croatian scientific community in the second instance. stfi from germany, institute of natural fibers from poland and leitat from spain have already accepted ttf's request for partnership during the project preparation phase, so the formal agreement was signed at the time of the kick-off meeting in zagreb. additionally, as planned in annex 1, face-to-face visits to new partner institutions were organised, in order to establish further partnerships. the first visit was to gze- grado zero espace, italy. in agreement with stfi, inmp and leitat, grado zero espace, a research performing sme from montelupo (italy) is selected to be the new strategic partner, for its experience in eu programmes and solid research base. empa will be a hosting institution without the status of the partnering institution and participation on the project management board. face-to-face visit to gze group of three croatian t-pot management board members (project coordinator sandra bischof vukusic, equipment manager tanja pusic and training manager edita vujasinovic), two german mb representatives (petra franitza and romy naumann) and polish representative in mb (malgorzata zimniewska) have visited partnering institution grado zero espace at their new premises at montelupo, italy on 28-29.05.2010. t- pot group visited factory ponte torto s.p.a., in prato. after the visit, a new partner grado zero espace have been successfully introduced and cooperation agreement have been signed. initiating partnership with empa empa was founded in 1880 in the cellars of zurich`polytechnic university, the forerunner of eth zurich. over more than 100 years of development, today empa is an interdisciplinary research and services institution for material sciences and technology development. their research activities cover the following domain: advanced materials and surfaces, civil and mechanical engineering, materials and systems for the protection & wellbeing of the body â information, reliability & simulation technology, mobility, energy and environment. the face-to face visit to empa, swiss federal laboratories for materials testing and research has been carried out on 17-19 november 2009. ph.d sandra bischof vukusic, professor of university of zagreb faculty of textile technology visited empas premises at st. gallen as part of activities of t.2.1. initiating a partnership and t.2.3. mentors know how transfer. the first task of the visit was to establish the research collaboartion of ttf and empa. in the presence of members of department for advanced fibers, prof. bischof vukusic held three presentations: 1) presentation of fp7-regpot-2008-1: t-pot project 2) presentation of tsrc portal 3) presentation of research topics within the project: alternative environmentally friendly processes and methods of cellulose modification. initiation of partnership with the institute for adriatic crops and karst reclamation former cooperation with association porart and town museum sibenik resulted with the new partnership and cooperation on the topic of preservation of cultural heritage and revitalisation of traditional crafts. face to face visit of ttf?s group to split was performed during 7-11.9.2011.   
result of this visit is project submitted to university of zagreb development fund, which was accepted and started from 1st january 2012. t 2.2. phd student secondments first research secondment at empa, switzerland was carried by marina turalija. dissertation topic, mentored by prof. bischof vukusic (ttf) and dr. sabyasachi gaan (empa), is entitled: antimicrobial functionalization of polylactide polymers through bulk and plasma modification. it is agreed between two organisations that the first part of experimental work would be performed at empa, st. gallen under the supervision of prof. ghan, after which the research is going to continue at ttf, zagreb. b.sc. turalija spent alltogether 13 months at empa, and last part of her stay was supported with the funds of unity through knowledge, gaining experience grant. more about this project is awailable at: http://www.ts-rc.eu/index.php?option=com\_content&view=article&id=239&itemid=83&lang=en second research secondment at university of ljubljana, slovenia was carried by eva magovac. on 19th november 2010 she started her research secondment at the premises of university of ljubljana, faculty of natural science and engineering, department of textile. during the one month secondment in ljubljana eva studied the effect of microencapsulated flame retardants on the flammability and thermal stability of fabrics under supervision of prof. petra forte tavcar, phd. the microcapsules have been developed by aero, chemical, graphic and paper manufacturers, d.d. celje, slovenia. the company deals with a wide range of paper and paper based materials; from repositionable products, self-adhesive materials for label industry to self-adhesive tapes, colours and glues, as well as microencapsulated products and is one of the oldest in this part of europe for such kind of products. (http://www.aero.si/ps/index\_engl.htm) third research secondment at institute of natural fibers and medicinal plants, poland was carried by zorana kovacevic. during the two months secondment at infmp (18th october â 15th december 2010), zorana kovacevic has studied the different methods of spanish broom plant maceration (water retting, osmotic degumming and enzymatic treatment) as well as physical properties of obtained fibres under the supervision of dr. malgorzata zimniewska, head of department of textile technology and the laboratory of physiological influence of textiles on human body. t.2.3. mentors know-how transfer as part of the activities of t 2.3. prof. sandra bischof vukusic visited empa and successfully completed first transfer. prof. bischof vukusic discussed the research topic of the ph.d thesis of marina turalija, who was on the research secondment at empa. her supervisor of research work was dr. sabyasachi gaan. phd is entitled: antimicrobial functionalization of polylactide polymers through bulk and plasma modification. public defence of the disertation topic was held on 17th february 2012, at the presence of prof. bischof vukusic and dr. gaan. second know-how transfer was to infmp (dr. malgorzata zimniewska) where zorana kovacevic was on her research secondment during the winter 2010. third know-how transfer was to university of ljubljana (prof. petra forte tavcer) where eva magovac was on her research secondment in duration of one month. t.2.4. up to 6 months secondments two research secondments were excecuted, to partner institution the leitat in spain. the secondees were ms. sanja ercegovic razic, from 16.06.2009 - 20.07.2009 and dr. antoneta tomljenovic, from 28.02.2011-18.03.2011. t.2.5. 2 week secondments: the execution of majority of secondments is postopned to the second project period due to delays that occured in wp4, equipment acquisition. only one short research secondment was executed within the first period. prof. sandra bischof vukusic visited textile sciences department of the university of georgia, ga, usa in the period 1.3.2009-20.03.2009. two designers from ttf: tihana mikâa perkovic and martinia ira glogar visited grado zero espace, both in duration of 1 week. third secondment was executed by vedran durasevic, from 01.01.2011-03.04.2011 who visited colour science department of university of leeds, uk. t 2.6. hosting scientists: the following scientists have been chosen as hosting scientists, due to the previous collaboration or due to the broadening of the ttfs research to new directions. 1. prof. charles q. yang, 27.10.2011.-3.11.2011., the university of georgia, ga, usa 2. dr. sabyasachi gaan, 17-19.10.2011., empa, st. gallen, switzerland 3. prof. david hui, 5.5.2012.-12.05.2012., university of new orleans, la, usa. t 2.7. evaluation of results: the main results of wp2 are newly established strategic partnerships and new opportunities for cooperation of ttfs researchers to do the part of their research in international environment.   
initiation of partnership with already recognized r&d partners has improved knowledge base of ttf and tsrc through knowledge transfer and adoption of new research methods and technologies, and opened access to international knowledge base and skills to local economy. ttf and tsrc can now better respond to the needs of croatian and regional textile sector offering broader spectrum of services, alone or jointly with strategic partners. t.2.8. sustainability of partnerships: a successful partnership included the following sustainability values to guide actions: â forming an internal sustainability team â conducting a facility operations assessment â defining topics/goals of joint interest: topics: technical textiles, composites, sustainable & green products, functional finishing goals: joint scientific publication, accreditation of testing methods, partnership in eu projects â evaluating project options: eu or national funded r&d projects â setting objectives and developing plans â implementing plans and assessing programs â measuring successes. by following these guidelines, new partners created motivating environment for long term partnership cooperation. the main contribution to the sustainability is given through creation of project pipeline and definition of long term joint research goals. one of the greatest benefits of individual partners is formation of t-pot network and sharing lessons learned with other members. wp3 â recruitment of experienced researchers the wp3 has 5 objectives: - raising the international competitiveness of ttf - forming a strong regional centre - reinforcing human capacities by recruiting experienced researchers - knowledge of unique technologies transferred to ttf - setting up new research directions leading to competitive advantage. t.3.1 prerequisites for integration - setting up measures and procedures to facilitate recruitment of experienced researchers - formation/upgrade of laboratory - setting up a research group for joint work. prior to entering the european union croatia has signed the european charter for researchers and the code of conduct for the recruitment of researchers. university of zagreb has signed this document on 11th march 2010. upon formation of sem laboratory, upgrading of textile science research laboratory, recruitment of experienced researcher and 3 phd students, the research group was set. the experience of prof katovic is of great importance for her new research group at the ttf. t.3.2 recruitment of an expert - announcing the need for recruitment of an expert worldwide - choice of candidates, under the code of conduct for the recruitment of researchers - organization of temporary employment - dissemination of obtained results in papers and conferences. as a part of t 3.2. activities, ttf recruited prof. andrea katovi?, expirienced researcher from italy. prof. katovic graduated in chemistry in 1985 and received a master of science degree in physical chemistry and radiochemistry in 1989 at the faculty of sciences and mathematics, university of zagreb. her phd thesis was accepted by the scientific council of the ruder boskovic institute in 1990 and issued in 1991 by university of zagreb. from 1985 till 1992 she was employed at the rudjer boskovic institute at the department of nuclear energy, first at the technology and protection laboratory for colloidal chemistry and later at the laboratory for synthesis of new materials. since 1993 she has been working at the university of calabria (unical). the university of calabria (http://www.unical.it) is a medium-sized university with about 36.000 students situated in southern italy, is a public institution established in 1972. her actual research activities comprise preparation and characterization of micro and mesoporous materials that are interesting for catalysis and adsorption as well as liquid phase heterogeneous catalysis with a special emphasis on ecosustainability of materials and processes. recruiting prof. katovic brought missing and much needed expertize to complement existing one at ttf, and enabled formation of new research group dealing with a topic not previously dealt with at ttf. by formation of new research group and purchasing of the equipment for thermal analysis and sem within the framework of t-pot project, a process of creation of new nanotechnology department at ttf is successfully completed. significant results of wp3 activities of wp3 produced two significant results - an experienced researcher is employed and new research group mentored by a respective researcher is formed and successfully integrated into the ttf research environment. additionally, procedures for short term employment and integration of experienced researchers have been improved, simplified and adopted as a new standard procedure.   
this initiative was a joint effort of the university of zagreb, four regpot 2008 project coordinators, the ministry of science, education and sport and agency for mobility and eu programmes. having in mind a croatian scientific community recently fully opened to era, adopting standard practice for employment and integration of experienced researchers have had significant impact to all future mobility actions. wp4 â acquisition and upgrade of research equipment objectives of the wp4 wp4 has five objectives: - upgrading of research equipment for in-depth scientific investigations - purchase and installation of equipment - education of personnel in use of equipment - creating flexible scientific research laboratories with modern equipment where groups of researches can work on specific projects - create conditions for cooperation with industry and joint projects all tasks of wp4 envisaged to be carried out are successfully completed. all the equipment purchased under the wp 4 acquisition & upgrading of research equipment is located in two laboratories at the department of textile chemistry & ecology in zagreb, croatia, according to the plans presented in grant agreement. t 4.1. - t.4.3. acquisition of the first set of the equipment (ftir, dsc, tga) the purchase of the first set of the equipment was performed under the public procurement no. evv-14/2009. the purchase contract no. 02-1851/2009 was signed on 15th october 2009 and the equipment was installed in january 2010. t.4.4. acquisition of second set of the equipment (sem, eds, sputter) the purchase of the second set of equipment was performed under the public procurement no. evv-5/2009. according to the contract, the ordered model fe sem mira ii lmu was installed at the premises of the department of textile chemistry & ecology, faculty of textile technology, university of zagreb in december 2009. all the equipment is located in two laboratories at the department of textile chemistry & ecology: â textile science research laboratory: dsc, ftir with tg-ir interface and tga, purchased from perkin elmer. â sem laboratory: dedicated exclusively to sem analyses. it was completely rearranged to obtain its best functionality. following equipment was purchased: a) microscope: fe-sem mira/lmu, tescan; b) eds detector for the chemical analyses: axs microanalysis quantax, bruker; c) sputtering device: sc7620-cf mini, quorum technologies. training for use of the equipment: two trainings were organized for each set of equipment: a basic level training immediately after the installation of the equipment, and an advanced level training 2-3 weeks after. t.4.5 presentation of new laboratories 1. the opening ceremony: 25.02.2010 . the opening ceremony was held in the presence of radovan fuchs, minister of science, education and sports, prof. aleksa bjelis, rector of the university of zagreb, hrvoje mestric, director of the directorate for science at the ministry of science, education and sport and ante rezo, senior advisor for textil and leather industry of ministry of economy, labour and entrepreneurship. coordinator of fp7-regpot-2008-1-229801: unlocking the textile research potentials (t-pot) project prof. sandra bischof vukusic has expressed the welcome and shortly presented the project activities. dean of the university of zagreb faculty of textile technology, prof. darko ujevic, held the first speech and presented scientific and educational activities of faculty of textile technology. the laboratories were opened officially by the minister of science, education and sports, radovan fuchs with the words of pride and satisfaction for the exceptional success of the faculty of textile technology. presentation was documented by national television and newspapers. a tv presentation in duration of 2 minutes is shown on national tv as a part of daily evening news in prime evening time. 2. presentation of laboratories during the textile forum, held on 2nd november 2011. the group attending the lecture of prof. yang consisted of aprox.75 scientist from different r&d institutions: representatives of 5 faculties and ruder boskovic institute. after the lecture, new laboratories were presented and prof. yang was awailable for the individual consultations with the interested phd candidates or young researchers. new contacts with other croatian spectroscopy and termoanalysis research groups have been made. 3. presentation of laboratories, during the annual conference of croatian microscopy society (cms), held on 2nd december 2011. due to the purchase of sem, faculty of textile technology was hosting the annual 2011 conference of cms. more that 70 members were present and after the officel programme, new laboratories were presented. wp5 â organisation of workshops and conferences objectives of wp5 â organiztion of workshops and conferences are the following: - know-how transfer and dissemination of scientific information - improving and developing skills at all levels of human resources - training activity in order to provide highly qualified and skilled workforce and to create a core group of well-trained researchers with the skills to spread the achieved success t 5.1. training in partners' premises in-house 3 day training events at partner (host) institutions: - leitat, spain (topics: functional finishing) - institute for natural fibres, poland (topic: multifunctional fibres, fibers reinforced composites) - stfi, germany, (topic: technical textiles, quality) - gze, italy (topic: functional design). 5.1.1. workshop at technological center leitat the workshop was held from june 16-19, 2009 at terrassa, spain. leitat is a technological center dedicated to providing services to other companies of the industrial sector, adding technological value not only to the products, but to their processing as well. while focusing on research, development, and innovation (r+d+i), these services offered by leitat, are clearly oriented and aimed to comply with a constantly changing market. the technological center leitat was founded in 1906. since its origins, leitat has prioritized its service vocation to companies and their needs, fostering, honesty, professionalism, respect for others and the environment. the promise to pursue the best technological solutions for other companies, has allowed leitat to collaborate closely with public institutions, state bodies, universities, and other technological centers, in search of the most efficient answers to the clientâs demands. a multidisciplinary staff, composed by phd, expert researchers and engineers, comprises the solid foundation of their development - not only on project development, but on the design and guidance as well, always directed towards the needs of the final client. leitat is currently working and collaborating with a wide variety of sectors that range from aeronautics, automotive industry, construction, energy, safety and protection systems, plastic and metal materials, maritime, healthcare, environment, furniture, to textile. technological cetrer leitat hosted a workshop for 12 paticipants from croatia: ten from faculty of textile technology and two croatian textile industry representatives from cateks and dorateks. the three-day workshop (june 17th - june 19th 2009), consisted of two lectures per day, including laboratory practices. the workshop topics were the following: 1. innovative textile finishing, presented by roshan paul, ph.d. 2. plasma technology applied to textiles, presented by lorenzo bautista 3. smart materials and technical textiles, presented by laurent aubouy, ph.d. 4. eco-design, presented by marta escamilla monell 5. properties, applications and uses of technical textiles, presented by javier jimenez romero 6. biotechnology in textile sector and textile care, presented by marta alaman & anna surribas casalprim, ph.d. 5.1.2. workshop at stfi stfi was founded on the 17 february 1992 by 24 enterprises and institutions of the textile industry. since december 2006 stfi has been associated to the chemnitz university of technology. stfi has 120 employees (researchers, laboratory assistants and technicians). each year, more than 100 r&d projects on regional, national and transnational level are carried out by stfi in the fields of technical textiles, nonwovens/films, warp-knitting/weaving, textile finishing/ecology, textile recycling, vegetable fibres, technical nets and ropes and textile materials research. saxon textile research institute (stfi) workshop was organised in chemnitz, germany, from 29th november to 4th december 2009. the workshop was held for 8 reserachers from the faculty of textile technology - assoc. prof. sandra bischof-vukusic, ph. d., prof. drago katovic, ph. d., assoc. prof. edita vujasinovic, ph. d., eva magovac, b. sc., junior researcher dragana kopitar, b. sc., assistant zaklina domjanic, b. sc., junior researcher maja somogyi, b. sc. and junior researcher snjezana brnada, b. sc., and two participants from industry mr. alan durek, b. sc. (regeneracija) and ms. marijana zeljko, b. sc. (kelteks). the workshop consists of the following activities: - a one-day visit to soex textile recycling company - a one-day workshop on technical textiles at stfi premises (including visit to stfi laboratories) - attendance at 9th stfi-colloquium - recycling for textiles (re4ex), a two-day colloquium organised by stfi on textile recycling a) visit to soex textile recycling company on 30th november 2009 t-pot group have visited soex company for recycling of old clothes (textile waste) and converting it into material for automotive or construction industry. old clothes are converted into valuable recycled product. the company is located in wolfen (sachsen-anhalt). soex employs approx. 550 workers, among them qualified it experts and experts in departments of sorting, warehouse and logistics. the supervisor processes orders (processes orders of the buyers of certain articles, with every buyer identified by his own number and a list of ordered articles), monitors movement of articles (the transport line is 5 km long) and looks for possible technical problems. there are three production areas in the company headquarters: re-wear, re-use and re-cycle. a detailed description of each of the processes and activities in the plant is presented in the deliverable d 5.1. soex visit report. b) workshop on technical textile recycling at stfi on tuesday 1st december the t-pot workshop started, organized by the stfi called âtechnical textiles/textile recyclingâ in the frame of eu project t-pot. the main topics of the workshop were the following: technical textiles - development trends and statistics - industrial applications of technical textiles - certification of personal protective equipment - certification of geosynthetics textile recycling - general introduction - recycling processes and machinery - testing of reclaimed fibres - practical recycling tests. the workshop was composed of 12 lectures in three blocks. a detailed report on topics and outcomes of the workshop are presented in the deliverable 5.3. report on stfi workshop. c) 9th stfi colloquium â recyclin ...

# T-POT

Project Acronym: T-POT

programme & topic: FP7-REGPOT REGPOT-2008-1-01

Most frequent returning words in objectives:

* ('research', 64)
* ('textile', 52)
* ('university', 32)
* ('prof.', 25)
* ('project', 24)
* ('equipment', 23)
* ('stfi', 20)
* ('croatian', 18)
* ('leitat', 18)
* ('empa', 18)
* ('workshop', 18)
* ('technology', 16)
* ('science', 15)
* ('researchers', 15)
* ('textiles', 15)
* ('t-pot', 14)
* ('zagreb', 14)
* ('laboratories', 14)
* ('held', 13)
* ('group', 13)
* ('faculty', 12)
* ('months', 12)
* ('transfer', 12)
* ('visit', 12)

executive summary:  
unlocking the croatian textile research potentials  
grant agreement 229801  
  
t-pot aims to reinforce research potentials of the faculty of textile technology of the university of zagreb (ttf) in order to strengthen the university sector to become one of the components of the national innovation system in croatia. the goals are to develop the capacity for breakthrough research, leading to innovative textile and textile related products, contributing in this way to the local industry, both nationally and in the region.   
  
the overall objective of t-pot is to unlock and upgrade the research potential of the faculty of textile technology (ttf), particularly its textile science research centre, enabling enhanced participation of croatian textile organisations in research activities at the european level, in order to support the harmonisation and integration process of croatian textile entities into the european research area.   
  
the reinforcement of ttf's research potentials is done through the reinforcement of human and material potential, as well as the research infrastructure. the recently established textile science research centre is upgraded to become one of the components of the national innovation. top scientists are attracted to the country for exchange of know-how and guidance of croatian textile manufacturers. that is why t-pot addresses all major issues of improvement of research capacities, addressed in fp7 capacities work programme: research potential, as topics for regpot-2008-1:  
  
1. reinforcement of s&t potential  
2. developing strategic partnerships with well established research groups  
3. supporting and mobilising the human & material resources  
4. facilitating communication between the centres having similar scientific interest  
5. disseminating scientific information and research results  
6. improving the responses to socio-economic needs (of croatia).  
  
project context and objectives:  
all objectives envisaged to be carried out during the project lifetime have been successfully completed and all tasks have been concluded. wp1: management t.1.1 organisation of periodical meetings - meetings of the management board (kick-off, progress meetings every 6 months) - meetings of the management team (progress meetings once per month) t.1.2 contract administration t.1.3 financial administration t.1.4 project reporting (midterm and final reports) the management team performed all envisaged tasks timely and in accordance with the best practices. effective project management procedures were detailed in project handbook (d.1.1). operational board meet on a regular monthly basis to discuss current project issues and manage possible changes while management board held regular 6 months based meetings. the quality assurance was controlled by constant monitoring of execution, reaching of milestones as well as producing of deliverables on time. wp2: developing strategic partnerships for know-how transfer t.2.1 initiating partnerships: with 3 institutes (stfi, leitat and infmp) and 1 sme (gze). additional partnership with empa and university of ljubljana.   
t.2.2 phd employment and secondments: employment of 3 young scientists. total secondments duration: 16 months. - marina turalija, 01.09.2009.-01.05.2010.; 01.07.2010.-01.08.2010.; 10.03.2011.-20.05.2011., empa, st. gallen, switzerland (13 montths) - eva magovac, 19.11.2010.-19.12.2010, university of ljubljana, slovenia (1 month) - zorana kovacevic, 18.10.2010.-18.12.2010., institute of natural fibers and medicinal plants (infmp), poznan, poland (2 months) t.2.3 mentors know-how transfer (visit of mentor to empa, infmp and university of ljubljana) - sandra bischof vukusic: -16.11.-20.11.2009, empa, department for advanced fibers, st. gallen, switzerland - 15 till 17 june 2010, infmp - november 2010, university of ljubljana, ljubljana, slovenia t-2.4 research secondments, up to 6 months within eu borders. total secondments duration: 4 months. - sanja ercegovic razic, from 16.06.2009.- 20.07.2009, leitat, terassa, spain (1 month) - antoneta tomljenovic, from 28.02.2011.-18.03.2011, leitat, terassa, spain (1 month) - vedran durasevic, from 01.01.2011.-03.04.2011, university of leeds, colour science department, leeds, uk (2 months) t.2.5 research secondments, up to 2 weeks: croatian scientists: - sandra bischof vukusic, 7.03.-27.03.2009, the university of georgia, textile sciences, dawson hall, athens, ga, usa (2 weeks) - tihana miksa perkovic, 31.01.2010 â 06.02.2010, gze, italy (1 week) - martinia ira glogar, 28.08.2011-03.09.2011, gze, italy, (1 week) eu scientists: - dr. thomas pfueller, 15.05.2011.-21.05.2011, stfi, chemnitz, germany (1 week) - edyta bogacz, 06.06.2011.-17.06.2011, infmp, poznan, poland (2 weeks) - moises moron soler, 18.02.2011.-26.02.2011, leitat, terassa, spain (1 week) t.2.6 hosting scientists - prof. charles q. yang, 27.10.2011-3.11.2011, university of georgia, ga, usa - dr. sabyaschi gaan, 17-19.10.2011, empa, switzerland - prof. david hui, 5.5.2012-12.5.2012, university of new orleans, usa. wp3: recruitment of experienced researchers (for know-how transfer and setting up of new research group t.3.3 employment of dr. andrea katovic, university of calabria, italy, in two shifts: - first shift 1.10.2009-1.3.2010 (5 months) - second shift 1.10.2010.-1.5.2011 (7 months). wp4: acquisition and upgrading of research equipment and setting up new laboratories t.4.1-t.4.4 acquisition of equipment (tga, dsc, ftir, sem) t.4.5 presentation of new laboratories at the following occasions: - opening ceremony: 25.02.2010. - workshop held by prof. charles q. yang on 2nd november 2011. - 19th annul conference of croatian microscopy society, held on 2nd december 2011. wp5: organisation of workshops and conferences t.5.1 training at partners premises â 3 in house 3-day trainings at leitat, stfi and inmfp. additional workshop was held at gze. - leitat (terrassa, spain) from 16 till 19 june 2009 - stfi (chemnitz, germany) from 29 november till 4 december 2009 - gze (montelupo, italy) from 27th-28th may 2010. - infmp (poznan, poland) from 15 till 17 june 2010. t.5.2 training organized by ttf in croatia - 2 worshops: - croatian chamber of economy (hgk): innovation, 21-23.09.2009. - croatian chamber of trades and crafts (hok): innovation management, 9 -11.05.2011. t.5.3 itc&dc 2010 conference â participation of all partnering institutions. - 3-6.10.2010. dubrovnik, croatia t.5.4 textile science & economy 2010 symposium, 16.01.2010. zagreb, croatia. - organisation of symposuim jointly with croatian chamber of commerce and croatian employer's organisation. participation of all partnering institutions at the round table. t.5.5 attendance at textile and related conferences: - aatcc, itc&dc, ts&e, tbis, autex attendence on numerous workshops. t.5.6 dissemination conference held in coordination with croatian chamber of trades and crafts, 16.02.2012. wp6: dissemination t 6.1 textile portal, http://www.ts-rc.eu/ t 6.2 t-pot project web site: http://www.t-pot.eu/ t.6.3 step web site, http://www.ttf.unizg.hr/step/about.htm t.6.4 postgraduate seminars, publication of book of scientific papers of young researchers: young scientists in protective textiles research (ed. s. bischof vukusic, d. katovic), 2011. t.6.5 textile forums: - ken greeson, cotton opportunities, cotton incorporated, nc, usa - ljubica cesnik, safety & protection, du pont international, slovenia - dinka liplin-prpic, power of innovation, schoeller textiles, switzerland t 6.6 presentations (tv, radio, annual conference etc.) - scientific knowledge, hrt 1 - 18.02.2012. obrtnik & partner (craftmen & partner), tv: hrt1 t.6.7 printing and publishing (brochures, flyers, promo materials, conference proceedings etc.). flyers: t-pot, tsrc, scientific tsrc laboratories books: ? young scientists in protective textiles research - functional protective textiles - t-pot monography conference proceedings: textile science & economy 2010   
  
project results:  
main s&t results wp2 â strategic partnerships and know-how transfer the main purpose of the wp2 is to develop strategic or twinning partnerships with related textile institutions. there are 3 objectives of wp2: - formation of strategic partnerships focused on capacity building through know-how transfer - sharing of research resources - joint initiatives for developing services in support of business and innovation t 2.1. initiating partnerships the aim of this task was to initiate new strategic partnerships with at least 3 but possibly more partnering institutions, in order to speed up integration of ttf and trsc into era and broaden the knowledge base of ttf and entire croatian scientific community in the second instance. stfi from germany, institute of natural fibers from poland and leitat from spain have already accepted ttf's request for partnership during the project preparation phase, so the formal agreement was signed at the time of the kick-off meeting in zagreb. additionally, as planned in annex 1, face-to-face visits to new partner institutions were organised, in order to establish further partnerships. the first visit was to gze- grado zero espace, italy. in agreement with stfi, inmp and leitat, grado zero espace, a research performing sme from montelupo (italy) is selected to be the new strategic partner, for its experience in eu programmes and solid research base. empa will be a hosting institution without the status of the partnering institution and participation on the project management board. face-to-face visit to gze group of three croatian t-pot management board members (project coordinator sandra bischof vukusic, equipment manager tanja pusic and training manager edita vujasinovic), two german mb representatives (petra franitza and romy naumann) and polish representative in mb (malgorzata zimniewska) have visited partnering institution grado zero espace at their new premises at montelupo, italy on 28-29.05.2010. t- pot group visited factory ponte torto s.p.a., in prato. after the visit, a new partner grado zero espace have been successfully introduced and cooperation agreement have been signed. initiating partnership with empa empa was founded in 1880 in the cellars of zurich`polytechnic university, the forerunner of eth zurich. over more than 100 years of development, today empa is an interdisciplinary research and services institution for material sciences and technology development. their research activities cover the following domain: advanced materials and surfaces, civil and mechanical engineering, materials and systems for the protection & wellbeing of the body â information, reliability & simulation technology, mobility, energy and environment. the face-to face visit to empa, swiss federal laboratories for materials testing and research has been carried out on 17-19 november 2009. ph.d sandra bischof vukusic, professor of university of zagreb faculty of textile technology visited empas premises at st. gallen as part of activities of t.2.1. initiating a partnership and t.2.3. mentors know how transfer. the first task of the visit was to establish the research collaboartion of ttf and empa. in the presence of members of department for advanced fibers, prof. bischof vukusic held three presentations: 1) presentation of fp7-regpot-2008-1: t-pot project 2) presentation of tsrc portal 3) presentation of research topics within the project: alternative environmentally friendly processes and methods of cellulose modification. initiation of partnership with the institute for adriatic crops and karst reclamation former cooperation with association porart and town museum sibenik resulted with the new partnership and cooperation on the topic of preservation of cultural heritage and revitalisation of traditional crafts. face to face visit of ttf?s group to split was performed during 7-11.9.2011.   
result of this visit is project submitted to university of zagreb development fund, which was accepted and started from 1st january 2012. t 2.2. phd student secondments first research secondment at empa, switzerland was carried by marina turalija. dissertation topic, mentored by prof. bischof vukusic (ttf) and dr. sabyasachi gaan (empa), is entitled: antimicrobial functionalization of polylactide polymers through bulk and plasma modification. it is agreed between two organisations that the first part of experimental work would be performed at empa, st. gallen under the supervision of prof. ghan, after which the research is going to continue at ttf, zagreb. b.sc. turalija spent alltogether 13 months at empa, and last part of her stay was supported with the funds of unity through knowledge, gaining experience grant. more about this project is awailable at: http://www.ts-rc.eu/index.php?option=com\_content&view=article&id=239&itemid=83&lang=en second research secondment at university of ljubljana, slovenia was carried by eva magovac. on 19th november 2010 she started her research secondment at the premises of university of ljubljana, faculty of natural science and engineering, department of textile. during the one month secondment in ljubljana eva studied the effect of microencapsulated flame retardants on the flammability and thermal stability of fabrics under supervision of prof. petra forte tavcar, phd. the microcapsules have been developed by aero, chemical, graphic and paper manufacturers, d.d. celje, slovenia. the company deals with a wide range of paper and paper based materials; from repositionable products, self-adhesive materials for label industry to self-adhesive tapes, colours and glues, as well as microencapsulated products and is one of the oldest in this part of europe for such kind of products. (http://www.aero.si/ps/index\_engl.htm) third research secondment at institute of natural fibers and medicinal plants, poland was carried by zorana kovacevic. during the two months secondment at infmp (18th october â 15th december 2010), zorana kovacevic has studied the different methods of spanish broom plant maceration (water retting, osmotic degumming and enzymatic treatment) as well as physical properties of obtained fibres under the supervision of dr. malgorzata zimniewska, head of department of textile technology and the laboratory of physiological influence of textiles on human body. t.2.3. mentors know-how transfer as part of the activities of t 2.3. prof. sandra bischof vukusic visited empa and successfully completed first transfer. prof. bischof vukusic discussed the research topic of the ph.d thesis of marina turalija, who was on the research secondment at empa. her supervisor of research work was dr. sabyasachi gaan. phd is entitled: antimicrobial functionalization of polylactide polymers through bulk and plasma modification. public defence of the disertation topic was held on 17th february 2012, at the presence of prof. bischof vukusic and dr. gaan. second know-how transfer was to infmp (dr. malgorzata zimniewska) where zorana kovacevic was on her research secondment during the winter 2010. third know-how transfer was to university of ljubljana (prof. petra forte tavcer) where eva magovac was on her research secondment in duration of one month. t.2.4. up to 6 months secondments two research secondments were excecuted, to partner institution the leitat in spain. the secondees were ms. sanja ercegovic razic, from 16.06.2009 - 20.07.2009 and dr. antoneta tomljenovic, from 28.02.2011-18.03.2011. t.2.5. 2 week secondments: the execution of majority of secondments is postopned to the second project period due to delays that occured in wp4, equipment acquisition. only one short research secondment was executed within the first period. prof. sandra bischof vukusic visited textile sciences department of the university of georgia, ga, usa in the period 1.3.2009-20.03.2009. two designers from ttf: tihana mikâa perkovic and martinia ira glogar visited grado zero espace, both in duration of 1 week. third secondment was executed by vedran durasevic, from 01.01.2011-03.04.2011 who visited colour science department of university of leeds, uk. t 2.6. hosting scientists: the following scientists have been chosen as hosting scientists, due to the previous collaboration or due to the broadening of the ttfs research to new directions. 1. prof. charles q. yang, 27.10.2011.-3.11.2011., the university of georgia, ga, usa 2. dr. sabyasachi gaan, 17-19.10.2011., empa, st. gallen, switzerland 3. prof. david hui, 5.5.2012.-12.05.2012., university of new orleans, la, usa. t 2.7. evaluation of results: the main results of wp2 are newly established strategic partnerships and new opportunities for cooperation of ttfs researchers to do the part of their research in international environment.   
initiation of partnership with already recognized r&d partners has improved knowledge base of ttf and tsrc through knowledge transfer and adoption of new research methods and technologies, and opened access to international knowledge base and skills to local economy. ttf and tsrc can now better respond to the needs of croatian and regional textile sector offering broader spectrum of services, alone or jointly with strategic partners. t.2.8. sustainability of partnerships: a successful partnership included the following sustainability values to guide actions: â forming an internal sustainability team â conducting a facility operations assessment â defining topics/goals of joint interest: topics: technical textiles, composites, sustainable & green products, functional finishing goals: joint scientific publication, accreditation of testing methods, partnership in eu projects â evaluating project options: eu or national funded r&d projects â setting objectives and developing plans â implementing plans and assessing programs â measuring successes. by following these guidelines, new partners created motivating environment for long term partnership cooperation. the main contribution to the sustainability is given through creation of project pipeline and definition of long term joint research goals. one of the greatest benefits of individual partners is formation of t-pot network and sharing lessons learned with other members. wp3 â recruitment of experienced researchers the wp3 has 5 objectives: - raising the international competitiveness of ttf - forming a strong regional centre - reinforcing human capacities by recruiting experienced researchers - knowledge of unique technologies transferred to ttf - setting up new research directions leading to competitive advantage. t.3.1 prerequisites for integration - setting up measures and procedures to facilitate recruitment of experienced researchers - formation/upgrade of laboratory - setting up a research group for joint work. prior to entering the european union croatia has signed the european charter for researchers and the code of conduct for the recruitment of researchers. university of zagreb has signed this document on 11th march 2010. upon formation of sem laboratory, upgrading of textile science research laboratory, recruitment of experienced researcher and 3 phd students, the research group was set. the experience of prof katovic is of great importance for her new research group at the ttf. t.3.2 recruitment of an expert - announcing the need for recruitment of an expert worldwide - choice of candidates, under the code of conduct for the recruitment of researchers - organization of temporary employment - dissemination of obtained results in papers and conferences. as a part of t 3.2. activities, ttf recruited prof. andrea katovi?, expirienced researcher from italy. prof. katovic graduated in chemistry in 1985 and received a master of science degree in physical chemistry and radiochemistry in 1989 at the faculty of sciences and mathematics, university of zagreb. her phd thesis was accepted by the scientific council of the ruder boskovic institute in 1990 and issued in 1991 by university of zagreb. from 1985 till 1992 she was employed at the rudjer boskovic institute at the department of nuclear energy, first at the technology and protection laboratory for colloidal chemistry and later at the laboratory for synthesis of new materials. since 1993 she has been working at the university of calabria (unical). the university of calabria (http://www.unical.it) is a medium-sized university with about 36.000 students situated in southern italy, is a public institution established in 1972. her actual research activities comprise preparation and characterization of micro and mesoporous materials that are interesting for catalysis and adsorption as well as liquid phase heterogeneous catalysis with a special emphasis on ecosustainability of materials and processes. recruiting prof. katovic brought missing and much needed expertize to complement existing one at ttf, and enabled formation of new research group dealing with a topic not previously dealt with at ttf. by formation of new research group and purchasing of the equipment for thermal analysis and sem within the framework of t-pot project, a process of creation of new nanotechnology department at ttf is successfully completed. significant results of wp3 activities of wp3 produced two significant results - an experienced researcher is employed and new research group mentored by a respective researcher is formed and successfully integrated into the ttf research environment. additionally, procedures for short term employment and integration of experienced researchers have been improved, simplified and adopted as a new standard procedure.   
this initiative was a joint effort of the university of zagreb, four regpot 2008 project coordinators, the ministry of science, education and sport and agency for mobility and eu programmes. having in mind a croatian scientific community recently fully opened to era, adopting standard practice for employment and integration of experienced researchers have had significant impact to all future mobility actions. wp4 â acquisition and upgrade of research equipment objectives of the wp4 wp4 has five objectives: - upgrading of research equipment for in-depth scientific investigations - purchase and installation of equipment - education of personnel in use of equipment - creating flexible scientific research laboratories with modern equipment where groups of researches can work on specific projects - create conditions for cooperation with industry and joint projects all tasks of wp4 envisaged to be carried out are successfully completed. all the equipment purchased under the wp 4 acquisition & upgrading of research equipment is located in two laboratories at the department of textile chemistry & ecology in zagreb, croatia, according to the plans presented in grant agreement. t 4.1. - t.4.3. acquisition of the first set of the equipment (ftir, dsc, tga) the purchase of the first set of the equipment was performed under the public procurement no. evv-14/2009. the purchase contract no. 02-1851/2009 was signed on 15th october 2009 and the equipment was installed in january 2010. t.4.4. acquisition of second set of the equipment (sem, eds, sputter) the purchase of the second set of equipment was performed under the public procurement no. evv-5/2009. according to the contract, the ordered model fe sem mira ii lmu was installed at the premises of the department of textile chemistry & ecology, faculty of textile technology, university of zagreb in december 2009. all the equipment is located in two laboratories at the department of textile chemistry & ecology: â textile science research laboratory: dsc, ftir with tg-ir interface and tga, purchased from perkin elmer. â sem laboratory: dedicated exclusively to sem analyses. it was completely rearranged to obtain its best functionality. following equipment was purchased: a) microscope: fe-sem mira/lmu, tescan; b) eds detector for the chemical analyses: axs microanalysis quantax, bruker; c) sputtering device: sc7620-cf mini, quorum technologies. training for use of the equipment: two trainings were organized for each set of equipment: a basic level training immediately after the installation of the equipment, and an advanced level training 2-3 weeks after. t.4.5 presentation of new laboratories 1. the opening ceremony: 25.02.2010 . the opening ceremony was held in the presence of radovan fuchs, minister of science, education and sports, prof. aleksa bjelis, rector of the university of zagreb, hrvoje mestric, director of the directorate for science at the ministry of science, education and sport and ante rezo, senior advisor for textil and leather industry of ministry of economy, labour and entrepreneurship. coordinator of fp7-regpot-2008-1-229801: unlocking the textile research potentials (t-pot) project prof. sandra bischof vukusic has expressed the welcome and shortly presented the project activities. dean of the university of zagreb faculty of textile technology, prof. darko ujevic, held the first speech and presented scientific and educational activities of faculty of textile technology. the laboratories were opened officially by the minister of science, education and sports, radovan fuchs with the words of pride and satisfaction for the exceptional success of the faculty of textile technology. presentation was documented by national television and newspapers. a tv presentation in duration of 2 minutes is shown on national tv as a part of daily evening news in prime evening time. 2. presentation of laboratories during the textile forum, held on 2nd november 2011. the group attending the lecture of prof. yang consisted of aprox.75 scientist from different r&d institutions: representatives of 5 faculties and ruder boskovic institute. after the lecture, new laboratories were presented and prof. yang was awailable for the individual consultations with the interested phd candidates or young researchers. new contacts with other croatian spectroscopy and termoanalysis research groups have been made. 3. presentation of laboratories, during the annual conference of croatian microscopy society (cms), held on 2nd december 2011. due to the purchase of sem, faculty of textile technology was hosting the annual 2011 conference of cms. more that 70 members were present and after the officel programme, new laboratories were presented. wp5 â organisation of workshops and conferences objectives of wp5 â organiztion of workshops and conferences are the following: - know-how transfer and dissemination of scientific information - improving and developing skills at all levels of human resources - training activity in order to provide highly qualified and skilled workforce and to create a core group of well-trained researchers with the skills to spread the achieved success t 5.1. training in partners' premises in-house 3 day training events at partner (host) institutions: - leitat, spain (topics: functional finishing) - institute for natural fibres, poland (topic: multifunctional fibres, fibers reinforced composites) - stfi, germany, (topic: technical textiles, quality) - gze, italy (topic: functional design). 5.1.1. workshop at technological center leitat the workshop was held from june 16-19, 2009 at terrassa, spain. leitat is a technological center dedicated to providing services to other companies of the industrial sector, adding technological value not only to the products, but to their processing as well. while focusing on research, development, and innovation (r+d+i), these services offered by leitat, are clearly oriented and aimed to comply with a constantly changing market. the technological center leitat was founded in 1906. since its origins, leitat has prioritized its service vocation to companies and their needs, fostering, honesty, professionalism, respect for others and the environment. the promise to pursue the best technological solutions for other companies, has allowed leitat to collaborate closely with public institutions, state bodies, universities, and other technological centers, in search of the most efficient answers to the clientâs demands. a multidisciplinary staff, composed by phd, expert researchers and engineers, comprises the solid foundation of their development - not only on project development, but on the design and guidance as well, always directed towards the needs of the final client. leitat is currently working and collaborating with a wide variety of sectors that range from aeronautics, automotive industry, construction, energy, safety and protection systems, plastic and metal materials, maritime, healthcare, environment, furniture, to textile. technological cetrer leitat hosted a workshop for 12 paticipants from croatia: ten from faculty of textile technology and two croatian textile industry representatives from cateks and dorateks. the three-day workshop (june 17th - june 19th 2009), consisted of two lectures per day, including laboratory practices. the workshop topics were the following: 1. innovative textile finishing, presented by roshan paul, ph.d. 2. plasma technology applied to textiles, presented by lorenzo bautista 3. smart materials and technical textiles, presented by laurent aubouy, ph.d. 4. eco-design, presented by marta escamilla monell 5. properties, applications and uses of technical textiles, presented by javier jimenez romero 6. biotechnology in textile sector and textile care, presented by marta alaman & anna surribas casalprim, ph.d. 5.1.2. workshop at stfi stfi was founded on the 17 february 1992 by 24 enterprises and institutions of the textile industry. since december 2006 stfi has been associated to the chemnitz university of technology. stfi has 120 employees (researchers, laboratory assistants and technicians). each year, more than 100 r&d projects on regional, national and transnational level are carried out by stfi in the fields of technical textiles, nonwovens/films, warp-knitting/weaving, textile finishing/ecology, textile recycling, vegetable fibres, technical nets and ropes and textile materials research. saxon textile research institute (stfi) workshop was organised in chemnitz, germany, from 29th november to 4th december 2009. the workshop was held for 8 reserachers from the faculty of textile technology - assoc. prof. sandra bischof-vukusic, ph. d., prof. drago katovic, ph. d., assoc. prof. edita vujasinovic, ph. d., eva magovac, b. sc., junior researcher dragana kopitar, b. sc., assistant zaklina domjanic, b. sc., junior researcher maja somogyi, b. sc. and junior researcher snjezana brnada, b. sc., and two participants from industry mr. alan durek, b. sc. (regeneracija) and ms. marijana zeljko, b. sc. (kelteks). the workshop consists of the following activities: - a one-day visit to soex textile recycling company - a one-day workshop on technical textiles at stfi premises (including visit to stfi laboratories) - attendance at 9th stfi-colloquium - recycling for textiles (re4ex), a two-day colloquium organised by stfi on textile recycling a) visit to soex textile recycling company on 30th november 2009 t-pot group have visited soex company for recycling of old clothes (textile waste) and converting it into material for automotive or construction industry. old clothes are converted into valuable recycled product. the company is located in wolfen (sachsen-anhalt). soex employs approx. 550 workers, among them qualified it experts and experts in departments of sorting, warehouse and logistics. the supervisor processes orders (processes orders of the buyers of certain articles, with every buyer identified by his own number and a list of ordered articles), monitors movement of articles (the transport line is 5 km long) and looks for possible technical problems. there are three production areas in the company headquarters: re-wear, re-use and re-cycle. a detailed description of each of the processes and activities in the plant is presented in the deliverable d 5.1. soex visit report. b) workshop on technical textile recycling at stfi on tuesday 1st december the t-pot workshop started, organized by the stfi called âtechnical textiles/textile recyclingâ in the frame of eu project t-pot. the main topics of the workshop were the following: technical textiles - development trends and statistics - industrial applications of technical textiles - certification of personal protective equipment - certification of geosynthetics textile recycling - general introduction - recycling processes and machinery - testing of reclaimed fibres - practical recycling tests. the workshop was composed of 12 lectures in three blocks. a detailed report on topics and outcomes of the workshop are presented in the deliverable 5.3. report on stfi workshop. c) 9th stfi colloquium â recyclin ...

# FASHION-ABLE

Project Acronym: FASHION-ABLE

programme & topic: FP7-NMP FoF.NMP.2011-4

Most frequent returning words in objectives:

* ('project', 27)
* ('products', 26)
* ('product', 23)
* ('groups', 15)
* ('footwear', 15)
* ('results', 15)
* ('manufacturing', 14)
* ('needs', 13)
* ('dissemination', 13)
* ('health', 12)
* ('event', 12)
* ('people', 11)
* ('clothing', 11)
* ('production', 11)
* ('wheelchair', 11)
* ('orthotics', 10)
* ('developed', 10)
* ('users', 10)
* ('goods', 9)
* ('processes', 9)
* ('order', 9)
* ('textile', 9)
* ('materials', 9)
* ('impact', 9)

executive summary:  
mass-customization of wearable products are offered as a higher added value to the broad public and had to compete with ready-to-wear offer. however, people with specific requirements are not covered with the current mass-customized products. this is the case of the elderly, disabled, diabetic and obese population groups when wearing textiles, clothing, footwear and textile-based orthotic goods. however, at present, available knowledge and flexibility of production equipment and machinery of smes operating in these traditional industries (even those that already offer made-to-measure products to the mass public) is unable to respond to the individual needs among such heterogeneous groups. the fashion-able project has solved this problem with: user framework defining and quantifying the relevant user attributes, new collaborative product customization services, new stretch-leatherâs manufacturing processes and equipment, new 3d-spacer fabricâs flexible manufacturing process and machinery, new textileâs finishing operations and equipment, an extended manufacturing order management structure and tools, life-cycle analysis instruments, and interoperable product data management tools.  
we use the end-user specifications in order to develop product customization services to be used by end-users and professionals (configurators). these tools manage the consumer characteristics and preferences which are the key to individual customization. a collaborative design environment made possible to define the morphological and functional characteristics of the end-user, to configure product style, and to individually personalize key product functionalities relevant to guarantee comfort and avoid health problems. the configurators are connected with an automatic method for adaptation of product dimensions to (atypical) individual shapes and postures. this method is applied to textile products (e.g. clothes and textile orthotics).  
  
in order to develop comfortable and fashion products (e.g. footwear and clothes) one of the results is the development of a new stretching textile, whose final mechanical properties are among the main added values, along with aesthetical and tactile feeling. the new materials combine stretch leather with 3d fabrics. during the project a new manufacturing machine was developed together with a cam system. a set of parameters based on past production quality checks control the main mechanical and thermic elements of the process, along with the devices, which verify their behaviour during machine operations by means of appropriate sensors. this approach enables the product developers to elaborate past results and take decision based on their verified quality.  
to adapt the pattern of the products to customer measures we have developed a process that uses the customer measures to determine the correlating reference size that matches best to the gathered dimensions. in the next step the determined reference size is adapted depending on the divergence of customer measurements to a defined basis set of measurements that was used to develop the reference sizes. for this made to measure (mtm) actions were developed in a morphotype specific way. this allows to cluster customer groups to morphotypes and to develop for those groups optimised mtm rules.   
in addition to the new customization processes, a new tool has been designed to support the constant reuse of environmental studies (life-cycle analysis) particularly for the supply of new technical materials (i.e. nano-materials) and sector-specific components (i.e. footbed) in order to counterbalance the high variability of the fashion product chain. epd general rules already provide a partial harmonization between the pcrs of the upstream materials (e.g. textiles) and the pcrs which are defined to downstream products containing such materials (e.g. footwear).  
finally, we have evaluated successfully the feasibility of the new customization processes with real costumers in germany, italy, belgium, poland and spain. we have delivered real products in 3 demonstration campaigns: shoes, clothes and textile orthotics. the costumers cover 3 target groups: obese people, wheelchair users, and people with special needs regarding foot shape and physiology (diabetic).  
  
project context and objectives:  
until now, mass-customization of wearable products has been offered as a higher added-value to the broad public and had to compete with ready-to-wear offer. however, there are population groups for which personalization is not just an added-value but a real need affecting their health and quality of life because off-the-shelf products do not meet their morphological or functional diversity.   
this is the case of the elderly, disabled, diabetic and obese population groups when wearing textiles, clothing, footwear and textile-based orthotic goods. but at present, available knowledge and flexibility of production equipment and machinery of smes operating in these traditional industries (even those that already offer made-to-measure products to the mass public) is unable to respond to the individual needs among such heterogeneous groups.  
  
fashion-able project aims at providing the european innovative and customization-concerned smes with the technological means that will enable the agile and eco-efficient production of personalised products addressing the complex individualised needs of growing market niches out of the scope of mass-produced goods in terms of health and performance.  
in particular, fashion-able project has implemented and demonstrate the new cross-sectorial technologies developed in industrial contexts in three concrete highly challenging target groups:  
diabetics developing diabetic foot (30 million) among which elderly and obese patients are in higher risk.  
physically disabled people requiring a wheelchair to move (5 million) among which over 2 million are aged 65+.  
musculoskeletal disorders (msds) sufferers (over 40 million) which prevalence increases with age and weight.  
  
project results:  
the fashion-able project aims at providing the european innovative and customization-concerned companies with the technological means that will enable the agile and eco-efficient production of personalised products in terms of health and performance, addressing the complex individualised needs of such growing market niches out of the scope of mass-produced goods. in particular, the fashion-able action implements and demonstrates in industrial contexts innovative cross-sectorial technologies developed for three highly challenging target groups: fashionable footwear for diabetic feet, fashionable clothing for wheelchair users, high-performing textile compression bandages. this section of the report introduces the methodology developed and presents the main s/t results/foregrounds results obtained.  
the main objectives achieved during the project are:  
o1. definition of a user framework that defines the relevant user attributes for each of targets issue of demonstration cases (footwear for neuropathic feet, clothing for wheelchair users and textile-based orthotics for pressure therapy).  
o2. development of new collaborative product customization services that enable the involvement of users and professionals (i.e. orthotic technicians) in the definition of requirements to tailor the products to individual functional needs and style at the point of sale (i.e. orthopaedic shop). they constitute the interface between the user/professional and the production site enabling to send an accurate product order to manufacture a fully customised product. three different applications have been developed: footwear, clothing and orthotics.  
o3. new stretch-leatherâs lean manufacturing processes, enabling to control and tailor mechanical (i.e. elasticity, resiliency, surface resistance, and thickness) properties of made-to-order leather components for footwear and leather garments while increasing productivity and eco-efficiency.  
o4. new 3d-spacer fabricâs flexible manufacturing process, enabling to control and tailor structural (i.e. thickness, stiffness and elasticity) properties of made-to-order textile components while increasing productivity and eco-efficiency.   
o5. new process of digital functionalization by airless fine spraying. the new process enables individual application for specific areas of the product componentsâ surface requiring specific functionalisations to improve user product-interaction (i.e. skin friction, skin care, anti-septic, anti-fungi, anti-bacterial, waterproof).  
o6. extended manufacturing order management and interoperable product data management tools structure and tools, integrating new services with new manufacturing solutions and machinery (pattern marking, cutting and sewing/stitching) used by footwear, orthotics and clothing manufacturers in order to ensure a seamless management and execution of single manufacturing orders for the individually configured product.  
o7. life-cycle analysis instruments, enabling to track, monitor and optimize the use of resources and environmental impact of products and along the processes involved. wp3, milestones m9 and m18.  
  
fashion-able provides to the european innovative and customization-concerned smes with the technological means that will enable the agile and eco-efficient production of personalised products addressing the complex individualised needs of growing market niches out of the scope of mass-produced goods in terms of health and performance.  
in particular, we have demonstrated that the methodology applied is feasible for developing s the new cross-sectorial technologies for three highly challenging target groups: fashionable footwear for diabetic feet, fashionable clothing for wheelchair users and high-performing textile compression bandages.  
the harmonized combination of developed technologies will have a direct impact on health, comfort, safety and quality of life of the targeted populations: diabetics developing diabetic feet; physically disabled people requiring a wheelchair; and sufferers from acute periods of musculoskeletal disorders which prevalence increases with age and weight. furthermore, the cross-sectorial approach will allow for extending and up-scaling functional customisation with little effort to future unexpected functionalities as well as to be transferred to other products and high demanding markets.  
  
potential impact:  
knowledge and technologies developed will overcome the common process barriers that currently hinder manufacturing companies from the addressed industries to effectively customise products to individuals:  
â¢ definition of the relations between user requirements depending on individual attributes and its translation into quantified product specifications for orthotics, footwear and clothing.  
â¢ true involvement of users and orthotic technicians in the definition of product requirements (both style and function) through effective communication supportive technologies.  
â¢ drastic reduction of current trial and error cycles followed to optimize product performance to individual requirements.  
â¢ flexibility of the production processes of leather and textiles, and integration of eco-friendly materials providing with new tailored-to-function properties into products that will enable to customise garment, footwear and orthotic components to the wider variety of higher performing functions required.   
â¢ introduction of new finishing operations enabling to locate multiple on-demand physiological and tribological properties in specific areas of the product.  
â¢ vertical integration along the supply chain to effectively shorten production cycles and delivery times.  
â¢ tracking, monitoring and optimizing the use of resources and environmental impact of products from a lifecycle perspective (production processes + use).  
  
main socioeconomic impacts expected from the implementation of project outcomes will be:  
â¢ raise competitiveness of european smes in the textiles, clothing, footwear and orthotics manufacturing industries. the project will provide them with a protectable business opportunity based on their ability to respond the highly individualised needs of currently unaddressed market niches.  
â¢ substantially improve the health, comfort, quality of life, social inclusion and independent living of the targeted population groups by the enlargement of product assortments meeting their needs and substantially improving end-users satisfaction and quality of life.  
â¢ reduce the environmental impact and optimize the use of resources currently made by the european textile, clothing, orthotics and footwear industries in their products and processes.  
â¢ set the technological basis and the industrial framework for extending and up-scaling functional customisation to other high demanding premium niches such as children or sports.  
  
the harmonised combination of the project results will have a direct impact on health, comfort, safety and quality of life of the targeted populations:  
â¢ diabetics developing diabetic feet (30 million) among which elderly and obese patients are in higher risk.  
â¢ physically disabled people requiring a wheelchair to move (5 million, where over 2 million aged 65+.  
â¢ sufferers of acute periods of musculoskeletal disorders (over 40 million) which prevalence increases with age and weight.  
in the particular target groups considered in the project, a significant impact in health is expected due to the functional and morphometric customisation of clothing, footwear and orthotics by: contribution to the reduction of the likelihood of developing pressure ulcers by 5% and the considerable improvement of sweat and moisture accumulation, skin care and hygienic conditions while following fashion trends. this will lead to an increase in product acceptability and comfort by a 40%, contributing directly to the fulfilment of usersâ individual physical, physiological and functional needs, and filling the current offer-demand gap. there features together with suitable prices will ensure a broad market penetration growing at 5% p.a.  
moreover fashion-able project aim not only to address the needs of european citizens, which represent a significant social problem in europe, but also to contribute to reducing public health system burden derived from savings on treatments for the health problems avoided.  
  
  
main dissemination activities  
  
the main objective of fashion-able dissemination activities was to outreach to consumer groups with special needs and related research and industrial community across the eu. thus, after the launch of the project the dissemination strategy and tools were set up to assure efficient communication of all projectâs developments and results to different audiences both within and outside the consortium.  
during the project a number of national and regional dissemination events were organised by the consortium in different european countries. these events became a strong communication activity of the project (detailed description below). the project has been present in international conferences. for example: ice 2012, ice 2014, manufuture conference 2103 and the european congress on innovations in textiles for health care 2013. moreover, a paper with the main results of the project has been submitted to the journal of computer integrated manufacturing.  
the dissemination largely benefitted from the availability of contents produced during the three demonstration campaigns: shoes, clothes and orthotics. the campaigns delivered the fashion-able products to real costumers from belgium, italy, germany, poland and spain, hence the campaigns proved that the results achieved during the project activities could be used in actual production contexts and ultimately were welcomed by the market. partners delivered customized products to highly challenging target groups: people that suffer diabetic foot and deformations, wheelchair users and obese people. the results of the campaign received very positive feedback and most costumers shown full satisfaction with the products delivered. some wheelchair users confirmed that the shirt is only comfortable and fits well, but this was the first time they could obtain a fashionable and attractive product.   
the final dissemination activities took large inspiration from the approach and the results of the demonstration campaign.  
  
ims-yourgoods event, valencia (spain), 27-28 february 2013   
the first fashion-able dissemination event took place in valencia, spain on 27-28 february 2013. a two days event was organised and coordinated by the hosting partner and consortium coordinator ibv, in cooperation with partners and external stakeholders. the fashion-able specific presentation was focused on the customer needs and product specification. the event offered the opportunity to present early results and discuss synergies concerning the activities of fashion-able and those of other related projects.   
to maximize the impact of the dissemination event beyond the some 40 participants present as well to allow further dissemination in longer period of time at additional costs all the materials (videos, presentations, photos) have been made available in the ibv web site: http://indumentaria.ibv.org/yourgoods.  
  
ofoonr general assembly, lublin (poland), 26-27 october 2013  
another fashion-able dissemination activity was organised in in october 2013 in lublin, poland, in the framework of the general assembly of ofoonr, the polish national association representing people with impaired motor functions, one of the target end-users of fashion-able. the event rolled out based on a three day calendar of activities, the first two days addressed mostly the sport performers with mobility impairment. on the final day, at the ofoonr general assembly bivolino presented fashion-able to the delegates of associations-members of ofoonr by using both the general presentation (fashion-able goals, partners, etc.) and the detailed presentation on the use of the online wheelchair configurator.  
   
  
eu open doors day, brussels (belgium), 17 may 2014  
in may 2014, the fashion-able partners organised a dissemination activity in brussels, belgium, within the european institutionsâ open doors event targeting the broad public raging from decision-makers to the end-users. the fashion-able partners presented the project in a separate stand placed in a highly visible location inside the headquarters of the european commission. at the result of the event, the achievements of fashion-able project were exhibited for some 15.000 visitors of the open doors event, including: fashionable shirts for wheelchairs users, customized shoes for feet shape altered by illness and high-performing textile compression bandages. features of the on-line tools for consumers to co-design and order âon demandâ wearable goods were demonstrated on a big screen next to the fashion-able stand. many guests asked details about the innovative processes and materials used to produce clothes. to strengthen the impact of the event the following articles were published:  
- euratex website: http://bit.ly/1hjkcrg   
- fashion-able website: http://www.fashionable-project.eu/node/670   
  
   
general assembly of predif, madrid (spain), 28 may 2014  
the following dissemination activity of fashion-able project was organised in madrid, spain, at the general assembly of predif â state representative platform of the physically disabled (spain). in the framework of this event the aims, achievements and current results of the fashion-able project were presented. the spanish members of the consortium demonstrated the configurator that enables people with disabilities to order personalised wearable goods online. with the help of some volunteers the functioning of the configurator and its features were tested at the stage. representatives of the organisations of people with physical disabilities (some of them wheelchair users) confirmed their willingness to support fashion-able project and promote the projectâs results in the future, so the stakeholders can benefit from the projectâs results most.   
the following articles were published in spanish media (national outlets and publications specialized on social topics):  
- comodidad para personas con movilidad reducida (once.es)  
- ropa adaptada: moda y comodidad para personas con movilidad reducida (lainformacion.com) - ropa adaptada: moda y comodidad para personas con movilidad reducida (eleconomista.es) - se presenta en madrid el proyecto fashion-able (predif.org)  
- predio presenta el catã¡logo de servicios accesibles a sus federaciones (periodico.laciudadaccesible.com)  
- ropa adaptada: moda y comodidad para personas con movilidad reducida (insercionsocial.com)   
   
  
large-scale public conference, brussels (belgium), 15-16 october 2014  
the final fashion-able conference was organised in brussels, belgium and was linked to the 3rd prosumer.net conference that is annually bringing together professionals, researchers and policy makers in the consumer goods sector. the fashion-able partners presented the project results and achievements during a separate panel. they shared the experience of testing the developed products during the demonstration campaigns. the fashion-able video was a strong dissemination tool along with the other promotional materials distributed during the conference. the conference audience watched the very first release of video productions specifically realised by the fashion-able project and coordinated by euratex.  
some 60 experts from 13 european countries joined the event to attend inspiring presentations on innovative consumer product concepts and prototypes as well as manufacturing and ict solutions to realise them and bring them to consumers, most of them resulting from collaborative european research projects such as fashion-able, mywear, addfactor and ctc.  
the upcoming political support and funding schemes by the european commission have been presented. the cosme programme with its design-based consumer goods market take-up action was presented by jean franã§ois aguinaga of dg enterprise & industry. roberta salonna from dg research & innovation presented the horizon 2020 programme with the fof research topic for "manufacturing of custom made parts for personalised products".   
the projectâs panel attracted much interest among research and business community, as the fashion-able project received funding from the european unionâs seventh framework programme and partners could share their experience in this type of research projects.   
the materials from prosumer.net and fashion-able conference are available: http://prosumernet.eu/. fashion-able videos: http://www.fashionable-project.eu/  
  
list of websites:  
  
http://www.fashionable-project.eu/

# FASHION-ABLE

Project Acronym: FASHION-ABLE

programme & topic: FP7-NMP FoF.NMP.2011-4

Most frequent returning words in objectives:

* ('project', 27)
* ('products', 26)
* ('product', 23)
* ('groups', 15)
* ('footwear', 15)
* ('results', 15)
* ('manufacturing', 14)
* ('needs', 13)
* ('dissemination', 13)
* ('health', 12)
* ('event', 12)
* ('people', 11)
* ('clothing', 11)
* ('production', 11)
* ('wheelchair', 11)
* ('orthotics', 10)
* ('developed', 10)
* ('users', 10)
* ('goods', 9)
* ('processes', 9)
* ('order', 9)
* ('textile', 9)
* ('materials', 9)
* ('impact', 9)

executive summary:  
mass-customization of wearable products are offered as a higher added value to the broad public and had to compete with ready-to-wear offer. however, people with specific requirements are not covered with the current mass-customized products. this is the case of the elderly, disabled, diabetic and obese population groups when wearing textiles, clothing, footwear and textile-based orthotic goods. however, at present, available knowledge and flexibility of production equipment and machinery of smes operating in these traditional industries (even those that already offer made-to-measure products to the mass public) is unable to respond to the individual needs among such heterogeneous groups. the fashion-able project has solved this problem with: user framework defining and quantifying the relevant user attributes, new collaborative product customization services, new stretch-leatherâs manufacturing processes and equipment, new 3d-spacer fabricâs flexible manufacturing process and machinery, new textileâs finishing operations and equipment, an extended manufacturing order management structure and tools, life-cycle analysis instruments, and interoperable product data management tools.  
we use the end-user specifications in order to develop product customization services to be used by end-users and professionals (configurators). these tools manage the consumer characteristics and preferences which are the key to individual customization. a collaborative design environment made possible to define the morphological and functional characteristics of the end-user, to configure product style, and to individually personalize key product functionalities relevant to guarantee comfort and avoid health problems. the configurators are connected with an automatic method for adaptation of product dimensions to (atypical) individual shapes and postures. this method is applied to textile products (e.g. clothes and textile orthotics).  
  
in order to develop comfortable and fashion products (e.g. footwear and clothes) one of the results is the development of a new stretching textile, whose final mechanical properties are among the main added values, along with aesthetical and tactile feeling. the new materials combine stretch leather with 3d fabrics. during the project a new manufacturing machine was developed together with a cam system. a set of parameters based on past production quality checks control the main mechanical and thermic elements of the process, along with the devices, which verify their behaviour during machine operations by means of appropriate sensors. this approach enables the product developers to elaborate past results and take decision based on their verified quality.  
to adapt the pattern of the products to customer measures we have developed a process that uses the customer measures to determine the correlating reference size that matches best to the gathered dimensions. in the next step the determined reference size is adapted depending on the divergence of customer measurements to a defined basis set of measurements that was used to develop the reference sizes. for this made to measure (mtm) actions were developed in a morphotype specific way. this allows to cluster customer groups to morphotypes and to develop for those groups optimised mtm rules.   
in addition to the new customization processes, a new tool has been designed to support the constant reuse of environmental studies (life-cycle analysis) particularly for the supply of new technical materials (i.e. nano-materials) and sector-specific components (i.e. footbed) in order to counterbalance the high variability of the fashion product chain. epd general rules already provide a partial harmonization between the pcrs of the upstream materials (e.g. textiles) and the pcrs which are defined to downstream products containing such materials (e.g. footwear).  
finally, we have evaluated successfully the feasibility of the new customization processes with real costumers in germany, italy, belgium, poland and spain. we have delivered real products in 3 demonstration campaigns: shoes, clothes and textile orthotics. the costumers cover 3 target groups: obese people, wheelchair users, and people with special needs regarding foot shape and physiology (diabetic).  
  
project context and objectives:  
until now, mass-customization of wearable products has been offered as a higher added-value to the broad public and had to compete with ready-to-wear offer. however, there are population groups for which personalization is not just an added-value but a real need affecting their health and quality of life because off-the-shelf products do not meet their morphological or functional diversity.   
this is the case of the elderly, disabled, diabetic and obese population groups when wearing textiles, clothing, footwear and textile-based orthotic goods. but at present, available knowledge and flexibility of production equipment and machinery of smes operating in these traditional industries (even those that already offer made-to-measure products to the mass public) is unable to respond to the individual needs among such heterogeneous groups.  
  
fashion-able project aims at providing the european innovative and customization-concerned smes with the technological means that will enable the agile and eco-efficient production of personalised products addressing the complex individualised needs of growing market niches out of the scope of mass-produced goods in terms of health and performance.  
in particular, fashion-able project has implemented and demonstrate the new cross-sectorial technologies developed in industrial contexts in three concrete highly challenging target groups:  
diabetics developing diabetic foot (30 million) among which elderly and obese patients are in higher risk.  
physically disabled people requiring a wheelchair to move (5 million) among which over 2 million are aged 65+.  
musculoskeletal disorders (msds) sufferers (over 40 million) which prevalence increases with age and weight.  
  
project results:  
the fashion-able project aims at providing the european innovative and customization-concerned companies with the technological means that will enable the agile and eco-efficient production of personalised products in terms of health and performance, addressing the complex individualised needs of such growing market niches out of the scope of mass-produced goods. in particular, the fashion-able action implements and demonstrates in industrial contexts innovative cross-sectorial technologies developed for three highly challenging target groups: fashionable footwear for diabetic feet, fashionable clothing for wheelchair users, high-performing textile compression bandages. this section of the report introduces the methodology developed and presents the main s/t results/foregrounds results obtained.  
the main objectives achieved during the project are:  
o1. definition of a user framework that defines the relevant user attributes for each of targets issue of demonstration cases (footwear for neuropathic feet, clothing for wheelchair users and textile-based orthotics for pressure therapy).  
o2. development of new collaborative product customization services that enable the involvement of users and professionals (i.e. orthotic technicians) in the definition of requirements to tailor the products to individual functional needs and style at the point of sale (i.e. orthopaedic shop). they constitute the interface between the user/professional and the production site enabling to send an accurate product order to manufacture a fully customised product. three different applications have been developed: footwear, clothing and orthotics.  
o3. new stretch-leatherâs lean manufacturing processes, enabling to control and tailor mechanical (i.e. elasticity, resiliency, surface resistance, and thickness) properties of made-to-order leather components for footwear and leather garments while increasing productivity and eco-efficiency.  
o4. new 3d-spacer fabricâs flexible manufacturing process, enabling to control and tailor structural (i.e. thickness, stiffness and elasticity) properties of made-to-order textile components while increasing productivity and eco-efficiency.   
o5. new process of digital functionalization by airless fine spraying. the new process enables individual application for specific areas of the product componentsâ surface requiring specific functionalisations to improve user product-interaction (i.e. skin friction, skin care, anti-septic, anti-fungi, anti-bacterial, waterproof).  
o6. extended manufacturing order management and interoperable product data management tools structure and tools, integrating new services with new manufacturing solutions and machinery (pattern marking, cutting and sewing/stitching) used by footwear, orthotics and clothing manufacturers in order to ensure a seamless management and execution of single manufacturing orders for the individually configured product.  
o7. life-cycle analysis instruments, enabling to track, monitor and optimize the use of resources and environmental impact of products and along the processes involved. wp3, milestones m9 and m18.  
  
fashion-able provides to the european innovative and customization-concerned smes with the technological means that will enable the agile and eco-efficient production of personalised products addressing the complex individualised needs of growing market niches out of the scope of mass-produced goods in terms of health and performance.  
in particular, we have demonstrated that the methodology applied is feasible for developing s the new cross-sectorial technologies for three highly challenging target groups: fashionable footwear for diabetic feet, fashionable clothing for wheelchair users and high-performing textile compression bandages.  
the harmonized combination of developed technologies will have a direct impact on health, comfort, safety and quality of life of the targeted populations: diabetics developing diabetic feet; physically disabled people requiring a wheelchair; and sufferers from acute periods of musculoskeletal disorders which prevalence increases with age and weight. furthermore, the cross-sectorial approach will allow for extending and up-scaling functional customisation with little effort to future unexpected functionalities as well as to be transferred to other products and high demanding markets.  
  
potential impact:  
knowledge and technologies developed will overcome the common process barriers that currently hinder manufacturing companies from the addressed industries to effectively customise products to individuals:  
â¢ definition of the relations between user requirements depending on individual attributes and its translation into quantified product specifications for orthotics, footwear and clothing.  
â¢ true involvement of users and orthotic technicians in the definition of product requirements (both style and function) through effective communication supportive technologies.  
â¢ drastic reduction of current trial and error cycles followed to optimize product performance to individual requirements.  
â¢ flexibility of the production processes of leather and textiles, and integration of eco-friendly materials providing with new tailored-to-function properties into products that will enable to customise garment, footwear and orthotic components to the wider variety of higher performing functions required.   
â¢ introduction of new finishing operations enabling to locate multiple on-demand physiological and tribological properties in specific areas of the product.  
â¢ vertical integration along the supply chain to effectively shorten production cycles and delivery times.  
â¢ tracking, monitoring and optimizing the use of resources and environmental impact of products from a lifecycle perspective (production processes + use).  
  
main socioeconomic impacts expected from the implementation of project outcomes will be:  
â¢ raise competitiveness of european smes in the textiles, clothing, footwear and orthotics manufacturing industries. the project will provide them with a protectable business opportunity based on their ability to respond the highly individualised needs of currently unaddressed market niches.  
â¢ substantially improve the health, comfort, quality of life, social inclusion and independent living of the targeted population groups by the enlargement of product assortments meeting their needs and substantially improving end-users satisfaction and quality of life.  
â¢ reduce the environmental impact and optimize the use of resources currently made by the european textile, clothing, orthotics and footwear industries in their products and processes.  
â¢ set the technological basis and the industrial framework for extending and up-scaling functional customisation to other high demanding premium niches such as children or sports.  
  
the harmonised combination of the project results will have a direct impact on health, comfort, safety and quality of life of the targeted populations:  
â¢ diabetics developing diabetic feet (30 million) among which elderly and obese patients are in higher risk.  
â¢ physically disabled people requiring a wheelchair to move (5 million, where over 2 million aged 65+.  
â¢ sufferers of acute periods of musculoskeletal disorders (over 40 million) which prevalence increases with age and weight.  
in the particular target groups considered in the project, a significant impact in health is expected due to the functional and morphometric customisation of clothing, footwear and orthotics by: contribution to the reduction of the likelihood of developing pressure ulcers by 5% and the considerable improvement of sweat and moisture accumulation, skin care and hygienic conditions while following fashion trends. this will lead to an increase in product acceptability and comfort by a 40%, contributing directly to the fulfilment of usersâ individual physical, physiological and functional needs, and filling the current offer-demand gap. there features together with suitable prices will ensure a broad market penetration growing at 5% p.a.  
moreover fashion-able project aim not only to address the needs of european citizens, which represent a significant social problem in europe, but also to contribute to reducing public health system burden derived from savings on treatments for the health problems avoided.  
  
  
main dissemination activities  
  
the main objective of fashion-able dissemination activities was to outreach to consumer groups with special needs and related research and industrial community across the eu. thus, after the launch of the project the dissemination strategy and tools were set up to assure efficient communication of all projectâs developments and results to different audiences both within and outside the consortium.  
during the project a number of national and regional dissemination events were organised by the consortium in different european countries. these events became a strong communication activity of the project (detailed description below). the project has been present in international conferences. for example: ice 2012, ice 2014, manufuture conference 2103 and the european congress on innovations in textiles for health care 2013. moreover, a paper with the main results of the project has been submitted to the journal of computer integrated manufacturing.  
the dissemination largely benefitted from the availability of contents produced during the three demonstration campaigns: shoes, clothes and orthotics. the campaigns delivered the fashion-able products to real costumers from belgium, italy, germany, poland and spain, hence the campaigns proved that the results achieved during the project activities could be used in actual production contexts and ultimately were welcomed by the market. partners delivered customized products to highly challenging target groups: people that suffer diabetic foot and deformations, wheelchair users and obese people. the results of the campaign received very positive feedback and most costumers shown full satisfaction with the products delivered. some wheelchair users confirmed that the shirt is only comfortable and fits well, but this was the first time they could obtain a fashionable and attractive product.   
the final dissemination activities took large inspiration from the approach and the results of the demonstration campaign.  
  
ims-yourgoods event, valencia (spain), 27-28 february 2013   
the first fashion-able dissemination event took place in valencia, spain on 27-28 february 2013. a two days event was organised and coordinated by the hosting partner and consortium coordinator ibv, in cooperation with partners and external stakeholders. the fashion-able specific presentation was focused on the customer needs and product specification. the event offered the opportunity to present early results and discuss synergies concerning the activities of fashion-able and those of other related projects.   
to maximize the impact of the dissemination event beyond the some 40 participants present as well to allow further dissemination in longer period of time at additional costs all the materials (videos, presentations, photos) have been made available in the ibv web site: http://indumentaria.ibv.org/yourgoods.  
  
ofoonr general assembly, lublin (poland), 26-27 october 2013  
another fashion-able dissemination activity was organised in in october 2013 in lublin, poland, in the framework of the general assembly of ofoonr, the polish national association representing people with impaired motor functions, one of the target end-users of fashion-able. the event rolled out based on a three day calendar of activities, the first two days addressed mostly the sport performers with mobility impairment. on the final day, at the ofoonr general assembly bivolino presented fashion-able to the delegates of associations-members of ofoonr by using both the general presentation (fashion-able goals, partners, etc.) and the detailed presentation on the use of the online wheelchair configurator.  
   
  
eu open doors day, brussels (belgium), 17 may 2014  
in may 2014, the fashion-able partners organised a dissemination activity in brussels, belgium, within the european institutionsâ open doors event targeting the broad public raging from decision-makers to the end-users. the fashion-able partners presented the project in a separate stand placed in a highly visible location inside the headquarters of the european commission. at the result of the event, the achievements of fashion-able project were exhibited for some 15.000 visitors of the open doors event, including: fashionable shirts for wheelchairs users, customized shoes for feet shape altered by illness and high-performing textile compression bandages. features of the on-line tools for consumers to co-design and order âon demandâ wearable goods were demonstrated on a big screen next to the fashion-able stand. many guests asked details about the innovative processes and materials used to produce clothes. to strengthen the impact of the event the following articles were published:  
- euratex website: http://bit.ly/1hjkcrg   
- fashion-able website: http://www.fashionable-project.eu/node/670   
  
   
general assembly of predif, madrid (spain), 28 may 2014  
the following dissemination activity of fashion-able project was organised in madrid, spain, at the general assembly of predif â state representative platform of the physically disabled (spain). in the framework of this event the aims, achievements and current results of the fashion-able project were presented. the spanish members of the consortium demonstrated the configurator that enables people with disabilities to order personalised wearable goods online. with the help of some volunteers the functioning of the configurator and its features were tested at the stage. representatives of the organisations of people with physical disabilities (some of them wheelchair users) confirmed their willingness to support fashion-able project and promote the projectâs results in the future, so the stakeholders can benefit from the projectâs results most.   
the following articles were published in spanish media (national outlets and publications specialized on social topics):  
- comodidad para personas con movilidad reducida (once.es)  
- ropa adaptada: moda y comodidad para personas con movilidad reducida (lainformacion.com) - ropa adaptada: moda y comodidad para personas con movilidad reducida (eleconomista.es) - se presenta en madrid el proyecto fashion-able (predif.org)  
- predio presenta el catã¡logo de servicios accesibles a sus federaciones (periodico.laciudadaccesible.com)  
- ropa adaptada: moda y comodidad para personas con movilidad reducida (insercionsocial.com)   
   
  
large-scale public conference, brussels (belgium), 15-16 october 2014  
the final fashion-able conference was organised in brussels, belgium and was linked to the 3rd prosumer.net conference that is annually bringing together professionals, researchers and policy makers in the consumer goods sector. the fashion-able partners presented the project results and achievements during a separate panel. they shared the experience of testing the developed products during the demonstration campaigns. the fashion-able video was a strong dissemination tool along with the other promotional materials distributed during the conference. the conference audience watched the very first release of video productions specifically realised by the fashion-able project and coordinated by euratex.  
some 60 experts from 13 european countries joined the event to attend inspiring presentations on innovative consumer product concepts and prototypes as well as manufacturing and ict solutions to realise them and bring them to consumers, most of them resulting from collaborative european research projects such as fashion-able, mywear, addfactor and ctc.  
the upcoming political support and funding schemes by the european commission have been presented. the cosme programme with its design-based consumer goods market take-up action was presented by jean franã§ois aguinaga of dg enterprise & industry. roberta salonna from dg research & innovation presented the horizon 2020 programme with the fof research topic for "manufacturing of custom made parts for personalised products".   
the projectâs panel attracted much interest among research and business community, as the fashion-able project received funding from the european unionâs seventh framework programme and partners could share their experience in this type of research projects.   
the materials from prosumer.net and fashion-able conference are available: http://prosumernet.eu/. fashion-able videos: http://www.fashionable-project.eu/  
  
list of websites:  
  
http://www.fashionable-project.eu/

# WASH&LOAD

Project Acronym: WASH&LOAD

programme & topic: FP7-SME SME-2011-2

Most frequent returning words in objectives:

* ('project', 55)
* ('process', 49)
* ('wash', 47)
* ('load', 47)
* ('system', 32)
* ('textile', 28)
* ('functionalities', 26)
* ('monitoring', 26)
* ('level', 22)
* ('laundry', 21)
* ('care', 20)
* ('life', 19)
* ('knowledge', 19)
* ('developed', 19)
* ('clothing', 18)
* ('cycle', 17)
* ('standards', 16)
* ('business', 15)
* ('results', 15)
* ('service', 15)
* ('tool', 15)
* ('activities', 15)
* ('development', 14)
* ('smes', 14)

executive summary:  
the wash&load project goal was to scientifically characterize latest achievements in science and technology for the development of guidelines and pre-normative research aimed at supporting the more than 20,000 smes involved in the functional clothing value chain in implementing cost-effective practices for reloading protective functionalities in protective clothing and bed linen textiles during life cycle, going beyond scattered attempts so far.  
the current solution for the ppes is a level of functionalisation that can last a predetermined number of washing cycles (e.g. 50). the ppe is supposed to be disposed after this number of cycles, independently on the real state of the equipment, although there are wide evidences that discrepancies between expected and real degradation may be substantial according to conditions of use. it may indeed be the case that protective functions have already declined before the number of standard washing cycles, because of excessive abrasion or other damages specific to end use. this drastically reduces the level of protection and furthermore exposes the employer to liabilities in case of accident or illness.  
the project aimed at a new product/process/service system where new functionalities are applied to protective clothing, after which they can be monitored and renewed during textile care. the new wash&load laundry system is based on a monitoring system controlling the concentration of chemicals in the bath during the re-functionalisation process ensuring that the correct level of functional agent is released on the textile; the re-functionalised garment is checked again after the process to assess the functionality level and validate the process. these elements provide the combination of a new product/process/service system, drastically extending the business model of the laundry business.  
addressing these challenges was beyond the capability of a single sme and required a collective r&d effort lead by sme groupings and associations at european and national level. for this reason the wash&load consortium was composed by 14 partners including 5 sme associations, 4 smes and 5 rtd performers from 4 different european countries and it was led by the italian engineering company dâappolonia. cinet, in her position as international umbrella organization for the textile care and technological knowledge center textile care (tkt), in the netherlands, had a leading role in defining the requirements for the development of the processes. dâappolonia developed the wash&load concept, together with tkt and iris-sw (switzerland) replaced then by the italian company idp srl. university of twente was responsible for the identification of the chemical agents able to functionalise the ppe. federation textile care netherlands (ftn) disseminated the project results and cared for trainings as well as ipr for the developed system. deutscher textilreinigungsverband (dtv) and vti both from germany had a leading role in building and spreading the project and the developed processes. lavans and varo srl performed a special role in the development of pilots and their validation. wsp systems was responsible for the implementation of the textile identification system and the monitoring software. texclubtec (italy) with stfi (germany) faced the standardization aspects.  
wash&load will have a relevant impact in the textile care sector enabling the transformation of the laundry industry from a washing business, often based on low skills and routine management into a full provider of comprehensive product service systems based on a thorough understanding of the scientific and technical background.  
wash&load expected impact will be twofold. on one side, the project, supporting the introduction of a new business model in the laundry, ppe and functional clothing care sector by shifting the ppe and functional clothing paradigm and replacing the actual fixed life cycle approach with monitoring of functionalities and consequent re-functionalisation, will open new economic perspective for the thousands of smes of the laundry sector and rationalising the whole protective clothing value chain, from functionalisation, to care and final use. this will lead to a saving within the overall value chain, thanks to the prolonged life cycle of the ppe and their extended use, demanding for higher quality clothing manufactured in eu-27. on the other hand, the wash&load approach, by means of a tracing and monitoring tool through the whole ppe life cycle, will encourage the introduction of new standards and norms for ppe and functional clothing functionalities, ensuring a high level protection of workers with important impact on safety and efficient use of resources.  
  
project context and objectives:  
the wash&load project aimed at introducing a new paradigm in the textile care sector by developing a refunctionalising process for ppe. refunctionalisation is applying functionalities to protective clothing, after which the functional properties can be monitored and validated by the textile service company.  
the wash&load project goal was to scientifically characterize latest achievements in science and technology for the development of guidelines and pre-normative research aimed at supporting the more than 20,000 smes involved in the functional clothing value chain in implementing cost-effective practices for reloading protective functionalities in protective clothing and bed linen textiles during life cycle, going beyond scattered attempts so far.  
the current solution for the ppes is a level of functionalisation that can last a predetermined number of washing cycles (e.g. 50). the ppe is supposed to be disposed after this number of cycles, independently on the real state of the equipment, although there are wide evidences that discrepancies between expected and real degradation may be substantial according to conditions of use. it may indeed be the case that protective functions have already declined before the number of standard washing cycles, because of excessive abrasion or other damages specific to end use. this drastically reduces the level of protection and furthermore exposes the employer to liabilities in case of accident or illness.  
the project aimed at a new product/process/service system where new functionalities are applied to protective clothing, after which they can be monitored and renewed during textile care. this process is called re-functionalizing. because of the large diversity of functionalities in the ppe of different employees, it has been decided that the project would be aimed at three specific features: flame retardancy, soil repellency and antibacterial qualities. the new wash&load laundry system is based on a monitoring system controlling the concentration of chemicals in the bath during the re-functionalisation process ensuring that the correct level of functional agent is released on the textile; the re-functionalised garment is checked again after the process to assess the functionality level and validate the process. these elements provide the combination of a new product/process/service system, drastically extending the business model of the laundry business.  
the main objectives of the project have been the scientific characterization of the latest achievements in chemical agents able to provide the target functionalities, the development of an integrated in-process monitoring system and the adaptation of the laundry process to include refunctionalisation by privileging approaches that require the minimum modification to the existing laundry equipment in order to guarantee the economical feasibility of the proposed system.   
moreover the project targeted the development of the pre-normative research tasks instrumental for the introduction of future standards as well as the implementation of a web based service and knowledge transfer infrastructure.   
specific objective of the project has been also to perform a detailed life cycle cost analysis enabling a sustainable business model, ensuring the large scale implementation of the new laundry process after the end of the project taking into account the needs of smes, keeping initial investments affordable and pursuing a short time payback by offering to customers a better performing service.  
addressing these challenges was beyond the capability of a single sme and required a collective r&d effort lead by sme groupings and associations at european and national level. for this reason the wash&load consortium was composed by 14 partners including 5 sme associations, 4 smes and 5 rtd performers from 4 different european countries and it was led by the italian engineering company dâappolonia. cinet, in her position as international umbrella organization for the textile care and technological knowledge center textile care (tkt), in the netherlands, had a leading role in defining the requirements for the development of the processes. dâappolonia developed the wash&load concept, together with tkt and iris-sw (switzerland) replaced then by the italian company idp srl. university of twente was responsible for the identification of the chemical agents able to functionalize the ppe. federation textile care netherlands (ftn) disseminated the project results and cared for trainings as well as ipr for the developed system. deutscher textilreinigungsverband (dtv) and vti both from germany had a leading role in building and spreading the project and the developed processes. lavans and varo srl performed a special role in the development of pilots and their validation. wsp systems was responsible for the implementation of the textile identification system and the monitoring software. texclubtec (italy) with stfi (germany) faced the standardization aspects.  
in a nutshell, the objectives of the project have been:  
â¢ to addresses the common challenge of smes in the textile and ppe value chain to face environmental concerns and growing low quality imports, helping the 20,000 european enterprises belonging to this sector to keep their added value;  
â¢ to introduce expertise and know-how on the latest scientific achievements for loading functionalities and traceability used in more rtd intensive sectors, as life sciences or electronics, thus reinforcing the technological basis of the textile service industry, through technology validation and transfer;  
â¢ to provides a platform to make the technology developed in the project available and easy exploitable during the demonstration and dissemination phase;  
â¢ to supports the introduction of cost-effective innovative technologies and processes which allow a reliable loading of functionalities during laundering, thus providing a scientific base for future norms and standards in this sector which could introduce a completely new business model with benefits and higher value for the end users.  
  
project results:  
at the end of the project, the target objectives of wash&load have been fully achieved. in the first period of the project, during the requirement phase, the work has been focused on an analysis of the trends in textile care service and ppe sectors, through the analysis of relevant patents and literature, as well as on the identification of routes/patterns for innovative approaches, enabling to focus the efforts towards the most promising and highest potential fields for the development of wash&load service.  
the opportunities for re-functionalisation technology of textiles and the most promising functionalities in relationship with targeted end-products of high interest for future competitiveness of the sector have been also identified by rtds and smes. in this way, the fields promising the highest added value have been highlighted for following efforts concentration.  
an accurate preliminary analysis of the market for textile service and the ppe market as well as an analysis of the developments in these markets has been carried out by month 3 of the project. from these analyses it has been concluded that the functionalization of textiles in the ppe market, but also in the textile service market as a whole, will be of major importance in the future. especially a trend to a market demand for multifunctional textile products of guaranteed level of functionality dedicated to the end-user was visible. refunctionalisation as proposed in the wash&load process appeared since the beginning an excellent solution to meet with these demands, offering the textile service industry to become a full-service provider to its customers creating a larger added value. furthermore, a detailed overview of the present-day laundry technology and process, including logistics and quality demands has been performed. most quality systems are based on the concept of a validated process. especially in the ppe-market, the use of international standards is very important, to guarantee the customer that the ppe-products meet with his demands. from the analysis of the scientific literature, it has been concluded that a large number of chemical and physical techniques were available for the functionalisation of textile materials. however, most literature was aimed at a more or less permanent functionalisation of textile materials instead of a refunctionalisation or reloading of textiles which is the main target of wash&load. the same can be concluded after having analyzed the patent databases. a number of suggestions for product opportunities has been defined for the three selected functionalities (antibacterial, soil repellancy and flame retardancy) as a starting point for the following research activities in the project.  
special attention has been paid in the definition of requirements and specifications for the wash&load product-service system identifying strengths and weaknesses of the current approach and physical constraints. the objective of this work has been the adaptation of the laundry process to include re-functionalisation service, privileging approaches that require the minimum modification to the existing laundry equipment in order to make easier the exploitation of the wash&load results and convenient from an economic point of view. this phase oriented the research activities during the project which have been focused on:   
1) the scientific characterization of the chemical agents able to provide the targeted functionality to the ppe: the functional agents for the 3 envisaged functionalities (antibacterial, soil repellancy and flame retardancy) have been selected and characterized.   
2) the development of a monitoring system able to control the functional agent concentrations during the laundry process and to assess the functionality level assessment: a prototype of the monitoring system have been developed and implemented in industrial washing machines.   
3) the overall reengineering of the laundry process.  
4) the definition of guidelines for the implementation of the refunctionalisation process in industrial laundries for the 3 selected functionalities.  
5) the development of the knowledge based platform as well as the of life cycle monitoring tool based on rfid technologies and able to monitor the overall process and the level of functionalisation on the ppe after the process.  
6) the validation of the overall concept in an industrial laundry during the demonstration activities.  
all these tasks have been successfully completed.   
more in details, at the end of the project, 9 chemical agents have been fully characterized at laboratory scale and a theoretical model able to enable the use of these chemical for the purpose of wash&load has been developed. as envisaged since the beginning of the project, three different pilot cases for the given functionalities (disinfection/antimicrobial, flame retardancy, water/soil repellence) have been realized during the rtd activities and after the selection of the two best cases out of three, the final validation in industrial setting has been carried out.   
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a fundamental part of the work has been the development of the web knowledge based platform and the decision support tool (dst) as main means of exploitation for the sme associations owners of the project results.  
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special attention during the last year of the project has been paid to the demonstration activities in order to fully validate the wash&load process/service/system.   
the task âfull scale demonstration of the processâ was devoted to the development of full scale demonstrator processes for two of the three target functionalities starting from the results of research activities carried out in the previous phase of the project. the functionalisation process has been validated by lavans and varo with the support of the sme-ags and with the significant contributions from all the rtd partners, to fruitfully transfer the knowledge developed.  
the textile identification process operated fine without problems during all the demonstration activities. the integration of the monitoring system in the lavans washing machine worked well.  
the measurements of the concentration of the chemicals on the fabric went well and the results appeared since the beginning to be well reproducible. the model to be used has been refined during the demonstration activities. all treatment data of the individual garment pieces were properly stored and connected to the treated pieces of garment. furthermore, all information of the individual batches was also properly stored. uploading of treatment and scanning data in the ict-system went smoothly without any problems.  
in order to validate the overall wash&load refunctionalisation process and the quality control, a specific experimental procedure was prepared.   
the results related to the large amount of data acquired during the demo phase have been carefully analysed and in particular the effectiveness of the functionalisation process and of the quality control system have been confirmed by the final tests carried out in laboratory according to the selected reference standards for the antibacterial activity and for the soil/water repellency validating in this way the wash&load functionalisation processes/service for the selected functionalities.  
in order to protect the wash&load concept a special attention has been paid to the ipr issues before disseminating the project results. the dissemination activities have been performed at national and european level in particular through fairs, conferences, workshops, article, wash&load website and press releases allowing the raising of awareness about the wash&load project result impact. special attention has been paid to the training activities targeting the sme-ags as well as the end-users. the last phase of the project has been devoted to the definition of the business model based on specific business cases and to the life cycle cost analysis (lcca) aiming at demonstrating the economical sustainability of the new process/service with respect to the traditional approach.   
in particular, the goal of the wash&load lcca analysis was to perform a comparative lcca (i.e. life cycle cost analysis) among the functionalised garment washed with state of the art (soa) process (i.e. existing solutions) versus the innovative process/service (i.e. functionalization process) developed within wash&load project framework.   
the existing solution foresees the washing of an already functionalised garment in a washing machine (including the drying phase) up to 50 times and then it has to be disposed in landfill.  
in the functionalization process, instead, the garment to be re-functionalised is inserted into a system which is composed by a washing machine (including the drying phase) having embedded a device that allows to monitor the functionalization of the garment and a sensor (i.e. sensing device) for monitoring the level of functionality on the dried garment after the process. the garment can be treated up to 100 times if it is a white workwear, such as for the food sector, or 150 times if it is a colored workwear washed on 60 â°c. in the performed lcca analysis both cases have been considered.  
the results showed that the economical impacts of the innovative wash&load process are lower than those of the soa process. in fact, even if the utilities and the investment costs are higher than in the soa process, the functionalised garment cost significantly influences the soa process final cost. the consequence is that the final cost associated with the soa washing process is a higher value than those associated with the innovative wash&load washing process.   
  
  
potential impact:  
the final result of the wash&load project is a new concept of a product service system in which ppe is functionalised and monitored during the use life through concepts of renewing of functionalities in the care and maintenance process. the functionality and the process are adjustable to the context of use and to the profile of the user; monitoring can validate the effect of functionalisation and degradation. in order to achieve this objective and to allow the implementation of the new concept, the work carried out by the rtd performer provided to the sme associations involved in the project the following 4 results:  
1) fully scientific characterization of chemical and functional agents   
2) monitoring system to control the functionalization process  
3) reloading process & related guidance   
4) knowledge management platform and life cycle monitoring tool to be exploited by the sme associations and enabling the selection of the most promising candidate solutions for a given functionality and end-use.  
wash&load will have a relevant impact in the textile care sector enabling the transformation of the laundry industry from a washing business, often based on low skills and routine management into a full provider of comprehensive product service systems based on a thorough understanding of the scientific and technical background.  
wash&load expected impact will be twofold. on one side, the project, supporting the introduction of a new business model in the laundry, ppe and functional clothing care sector by shifting the ppe and functional clothing paradigm and replacing the actual fixed life cycle approach with monitoring of functionalities and consequent re-functionalisation, will open new economic perspective for the thousands of smes of the laundry sector and rationalising the whole protective clothing value chain, from functionalisation, to care and final use. this will lead to a saving within the overall value chain, thanks to the prolonged life cycle of the ppe of each garment and their extended use, demanding for higher quality clothing manufactured in eu-27. on the other hand, the wash&load approach, by means of a tracing and monitoring tool through the whole ppe life cycle, will encourage the introduction of new standards and norms for ppe and functional clothing functionalities, ensuring a high level protection of workers with important impact on safety and efficient use of resources.  
the societal impact of the project comprises both an enhancement in workersâ safety thanks to the validated re-functionalisation of workwear and possible benefits for the whole industrial chain from the higher competitiveness of european manufacturers and from the extension of the ppe and functional clothing value chain. the project aimed at a market of 140 million users of personal protective equipment (ppe) in europe. despite the commissionâs great efforts in workersâ health care and accident prevention, in europe there are 4 million accidents on workplace every year, causing the death of 7,400 people. the main objective of the project was to increase protection for workers through an integrated product-process service system. the project focused on a number of business cases for which the technologies developed can be relevant: healthcare, catering and food industry workers (hygiene and skin protection); maintenance services and utilities (soil repellancy). moreover the project could have relevant perspectives for work wears for chemical and manufacturing industries. these sectors combined represent 90% of ppe currently used covering almost 60% of workers in industry. from the point of view of social impact, it is important to underline that setting up an improved new standard for ppe production, as fostered by wash&load initiative, will help european ppe manufacturers in overcoming the competition from low labour cost countries, an issue of utmost importance considering that ppe exports are forecast to grow by 50% in the next few years.   
as far as the dissemination of wash&load is concerned, the goal of communication and dissemination activities performed within the project was to reach the widest impact on european textile care sector, as well as on operational activities to exploit innovative processes and services to improve european competitiveness.  
as such, an efficient overall communication strategy has been set up in order to realize the targeted impact.  
with this respect, the wash&load consortium developed different contents and selected different information channels and events, formulated ad-hoc communication strategies targeting the different industries to be addressed, thus giving qualified answers to all different types of target audiences.  
within this framework, the following criteria have been fulfilled:  
-contents have been carefully selected and implemented in function of the target audience;  
-information channels have been carefully selected in order to best perform in function of target audience and contents.   
project partners have been the communicators with the aim to contact target groups. each partner played a specific role in communication activities.   
as international umbrella association cinet prepared, organized and coordinated execution of the activities ...

# WASH&LOAD

Project Acronym: WASH&LOAD

programme & topic: FP7-SME SME-2011-2

Most frequent returning words in objectives:

* ('project', 55)
* ('process', 49)
* ('wash', 47)
* ('load', 47)
* ('system', 32)
* ('textile', 28)
* ('functionalities', 26)
* ('monitoring', 26)
* ('level', 22)
* ('laundry', 21)
* ('care', 20)
* ('life', 19)
* ('knowledge', 19)
* ('developed', 19)
* ('clothing', 18)
* ('cycle', 17)
* ('standards', 16)
* ('business', 15)
* ('results', 15)
* ('service', 15)
* ('tool', 15)
* ('activities', 15)
* ('development', 14)
* ('smes', 14)

executive summary:  
the wash&load project goal was to scientifically characterize latest achievements in science and technology for the development of guidelines and pre-normative research aimed at supporting the more than 20,000 smes involved in the functional clothing value chain in implementing cost-effective practices for reloading protective functionalities in protective clothing and bed linen textiles during life cycle, going beyond scattered attempts so far.  
the current solution for the ppes is a level of functionalisation that can last a predetermined number of washing cycles (e.g. 50). the ppe is supposed to be disposed after this number of cycles, independently on the real state of the equipment, although there are wide evidences that discrepancies between expected and real degradation may be substantial according to conditions of use. it may indeed be the case that protective functions have already declined before the number of standard washing cycles, because of excessive abrasion or other damages specific to end use. this drastically reduces the level of protection and furthermore exposes the employer to liabilities in case of accident or illness.  
the project aimed at a new product/process/service system where new functionalities are applied to protective clothing, after which they can be monitored and renewed during textile care. the new wash&load laundry system is based on a monitoring system controlling the concentration of chemicals in the bath during the re-functionalisation process ensuring that the correct level of functional agent is released on the textile; the re-functionalised garment is checked again after the process to assess the functionality level and validate the process. these elements provide the combination of a new product/process/service system, drastically extending the business model of the laundry business.  
addressing these challenges was beyond the capability of a single sme and required a collective r&d effort lead by sme groupings and associations at european and national level. for this reason the wash&load consortium was composed by 14 partners including 5 sme associations, 4 smes and 5 rtd performers from 4 different european countries and it was led by the italian engineering company dâappolonia. cinet, in her position as international umbrella organization for the textile care and technological knowledge center textile care (tkt), in the netherlands, had a leading role in defining the requirements for the development of the processes. dâappolonia developed the wash&load concept, together with tkt and iris-sw (switzerland) replaced then by the italian company idp srl. university of twente was responsible for the identification of the chemical agents able to functionalise the ppe. federation textile care netherlands (ftn) disseminated the project results and cared for trainings as well as ipr for the developed system. deutscher textilreinigungsverband (dtv) and vti both from germany had a leading role in building and spreading the project and the developed processes. lavans and varo srl performed a special role in the development of pilots and their validation. wsp systems was responsible for the implementation of the textile identification system and the monitoring software. texclubtec (italy) with stfi (germany) faced the standardization aspects.  
wash&load will have a relevant impact in the textile care sector enabling the transformation of the laundry industry from a washing business, often based on low skills and routine management into a full provider of comprehensive product service systems based on a thorough understanding of the scientific and technical background.  
wash&load expected impact will be twofold. on one side, the project, supporting the introduction of a new business model in the laundry, ppe and functional clothing care sector by shifting the ppe and functional clothing paradigm and replacing the actual fixed life cycle approach with monitoring of functionalities and consequent re-functionalisation, will open new economic perspective for the thousands of smes of the laundry sector and rationalising the whole protective clothing value chain, from functionalisation, to care and final use. this will lead to a saving within the overall value chain, thanks to the prolonged life cycle of the ppe and their extended use, demanding for higher quality clothing manufactured in eu-27. on the other hand, the wash&load approach, by means of a tracing and monitoring tool through the whole ppe life cycle, will encourage the introduction of new standards and norms for ppe and functional clothing functionalities, ensuring a high level protection of workers with important impact on safety and efficient use of resources.  
  
project context and objectives:  
the wash&load project aimed at introducing a new paradigm in the textile care sector by developing a refunctionalising process for ppe. refunctionalisation is applying functionalities to protective clothing, after which the functional properties can be monitored and validated by the textile service company.  
the wash&load project goal was to scientifically characterize latest achievements in science and technology for the development of guidelines and pre-normative research aimed at supporting the more than 20,000 smes involved in the functional clothing value chain in implementing cost-effective practices for reloading protective functionalities in protective clothing and bed linen textiles during life cycle, going beyond scattered attempts so far.  
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the project aimed at a new product/process/service system where new functionalities are applied to protective clothing, after which they can be monitored and renewed during textile care. this process is called re-functionalizing. because of the large diversity of functionalities in the ppe of different employees, it has been decided that the project would be aimed at three specific features: flame retardancy, soil repellency and antibacterial qualities. the new wash&load laundry system is based on a monitoring system controlling the concentration of chemicals in the bath during the re-functionalisation process ensuring that the correct level of functional agent is released on the textile; the re-functionalised garment is checked again after the process to assess the functionality level and validate the process. these elements provide the combination of a new product/process/service system, drastically extending the business model of the laundry business.  
the main objectives of the project have been the scientific characterization of the latest achievements in chemical agents able to provide the target functionalities, the development of an integrated in-process monitoring system and the adaptation of the laundry process to include refunctionalisation by privileging approaches that require the minimum modification to the existing laundry equipment in order to guarantee the economical feasibility of the proposed system.   
moreover the project targeted the development of the pre-normative research tasks instrumental for the introduction of future standards as well as the implementation of a web based service and knowledge transfer infrastructure.   
specific objective of the project has been also to perform a detailed life cycle cost analysis enabling a sustainable business model, ensuring the large scale implementation of the new laundry process after the end of the project taking into account the needs of smes, keeping initial investments affordable and pursuing a short time payback by offering to customers a better performing service.  
addressing these challenges was beyond the capability of a single sme and required a collective r&d effort lead by sme groupings and associations at european and national level. for this reason the wash&load consortium was composed by 14 partners including 5 sme associations, 4 smes and 5 rtd performers from 4 different european countries and it was led by the italian engineering company dâappolonia. cinet, in her position as international umbrella organization for the textile care and technological knowledge center textile care (tkt), in the netherlands, had a leading role in defining the requirements for the development of the processes. dâappolonia developed the wash&load concept, together with tkt and iris-sw (switzerland) replaced then by the italian company idp srl. university of twente was responsible for the identification of the chemical agents able to functionalize the ppe. federation textile care netherlands (ftn) disseminated the project results and cared for trainings as well as ipr for the developed system. deutscher textilreinigungsverband (dtv) and vti both from germany had a leading role in building and spreading the project and the developed processes. lavans and varo srl performed a special role in the development of pilots and their validation. wsp systems was responsible for the implementation of the textile identification system and the monitoring software. texclubtec (italy) with stfi (germany) faced the standardization aspects.  
in a nutshell, the objectives of the project have been:  
â¢ to addresses the common challenge of smes in the textile and ppe value chain to face environmental concerns and growing low quality imports, helping the 20,000 european enterprises belonging to this sector to keep their added value;  
â¢ to introduce expertise and know-how on the latest scientific achievements for loading functionalities and traceability used in more rtd intensive sectors, as life sciences or electronics, thus reinforcing the technological basis of the textile service industry, through technology validation and transfer;  
â¢ to provides a platform to make the technology developed in the project available and easy exploitable during the demonstration and dissemination phase;  
â¢ to supports the introduction of cost-effective innovative technologies and processes which allow a reliable loading of functionalities during laundering, thus providing a scientific base for future norms and standards in this sector which could introduce a completely new business model with benefits and higher value for the end users.  
  
project results:  
at the end of the project, the target objectives of wash&load have been fully achieved. in the first period of the project, during the requirement phase, the work has been focused on an analysis of the trends in textile care service and ppe sectors, through the analysis of relevant patents and literature, as well as on the identification of routes/patterns for innovative approaches, enabling to focus the efforts towards the most promising and highest potential fields for the development of wash&load service.  
the opportunities for re-functionalisation technology of textiles and the most promising functionalities in relationship with targeted end-products of high interest for future competitiveness of the sector have been also identified by rtds and smes. in this way, the fields promising the highest added value have been highlighted for following efforts concentration.  
an accurate preliminary analysis of the market for textile service and the ppe market as well as an analysis of the developments in these markets has been carried out by month 3 of the project. from these analyses it has been concluded that the functionalization of textiles in the ppe market, but also in the textile service market as a whole, will be of major importance in the future. especially a trend to a market demand for multifunctional textile products of guaranteed level of functionality dedicated to the end-user was visible. refunctionalisation as proposed in the wash&load process appeared since the beginning an excellent solution to meet with these demands, offering the textile service industry to become a full-service provider to its customers creating a larger added value. furthermore, a detailed overview of the present-day laundry technology and process, including logistics and quality demands has been performed. most quality systems are based on the concept of a validated process. especially in the ppe-market, the use of international standards is very important, to guarantee the customer that the ppe-products meet with his demands. from the analysis of the scientific literature, it has been concluded that a large number of chemical and physical techniques were available for the functionalisation of textile materials. however, most literature was aimed at a more or less permanent functionalisation of textile materials instead of a refunctionalisation or reloading of textiles which is the main target of wash&load. the same can be concluded after having analyzed the patent databases. a number of suggestions for product opportunities has been defined for the three selected functionalities (antibacterial, soil repellancy and flame retardancy) as a starting point for the following research activities in the project.  
special attention has been paid in the definition of requirements and specifications for the wash&load product-service system identifying strengths and weaknesses of the current approach and physical constraints. the objective of this work has been the adaptation of the laundry process to include re-functionalisation service, privileging approaches that require the minimum modification to the existing laundry equipment in order to make easier the exploitation of the wash&load results and convenient from an economic point of view. this phase oriented the research activities during the project which have been focused on:   
1) the scientific characterization of the chemical agents able to provide the targeted functionality to the ppe: the functional agents for the 3 envisaged functionalities (antibacterial, soil repellancy and flame retardancy) have been selected and characterized.   
2) the development of a monitoring system able to control the functional agent concentrations during the laundry process and to assess the functionality level assessment: a prototype of the monitoring system have been developed and implemented in industrial washing machines.   
3) the overall reengineering of the laundry process.  
4) the definition of guidelines for the implementation of the refunctionalisation process in industrial laundries for the 3 selected functionalities.  
5) the development of the knowledge based platform as well as the of life cycle monitoring tool based on rfid technologies and able to monitor the overall process and the level of functionalisation on the ppe after the process.  
6) the validation of the overall concept in an industrial laundry during the demonstration activities.  
all these tasks have been successfully completed.   
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during the project, an inventory of all relevant rules, standards and policies at national and international level in the ppe and textile care sectors has been carried out. then the compliance to standards of all project results have been analysed and the activities aiming at the definition of the need of new standards have been completed by producing guidelines for the new process/product/service.   
as a matter of fact, wash&load is a novelty and therefore laundries implementing wash&load must validate their processes to make sure that antimicrobial and/or soil repellent (the two functionalities selected for the validation at the end of the project) but also all other functionalities reach the required levels and meet the requirements. it is expected that wash&load will improve in this respect the properties of garments. refunctionalisation aspect is not taken into account in the current standards. however, the development of new standards or revising existing ones are long-lasting processes and private parties must have an interest in participating and funding these projects. next to this, wash&load is a new, innovative concept yet to be introduced on the market. it is reasonable to expect that evaluations may lead to modifications of requirements. therefore it has been proposed at the end of the project to set up guidelines for the wash&load system and properties so the suppliers and customers have insight in the requirements and the minimum level of performance. this approach can fill the lack of suitable standards for the functionalities and the wash&load system.  
special attention during the last year of the project has been paid to the demonstration activities in order to fully validate the wash&load process/service/system.   
the task âfull scale demonstration of the processâ was devoted to the development of full scale demonstrator processes for two of the three target functionalities starting from the results of research activities carried out in the previous phase of the project. the functionalisation process has been validated by lavans and varo with the support of the sme-ags and with the significant contributions from all the rtd partners, to fruitfully transfer the knowledge developed.  
the textile identification process operated fine without problems during all the demonstration activities. the integration of the monitoring system in the lavans washing machine worked well.  
the measurements of the concentration of the chemicals on the fabric went well and the results appeared since the beginning to be well reproducible. the model to be used has been refined during the demonstration activities. all treatment data of the individual garment pieces were properly stored and connected to the treated pieces of garment. furthermore, all information of the individual batches was also properly stored. uploading of treatment and scanning data in the ict-system went smoothly without any problems.  
in order to validate the overall wash&load refunctionalisation process and the quality control, a specific experimental procedure was prepared.   
the results related to the large amount of data acquired during the demo phase have been carefully analysed and in particular the effectiveness of the functionalisation process and of the quality control system have been confirmed by the final tests carried out in laboratory according to the selected reference standards for the antibacterial activity and for the soil/water repellency validating in this way the wash&load functionalisation processes/service for the selected functionalities.  
in order to protect the wash&load concept a special attention has been paid to the ipr issues before disseminating the project results. the dissemination activities have been performed at national and european level in particular through fairs, conferences, workshops, article, wash&load website and press releases allowing the raising of awareness about the wash&load project result impact. special attention has been paid to the training activities targeting the sme-ags as well as the end-users. the last phase of the project has been devoted to the definition of the business model based on specific business cases and to the life cycle cost analysis (lcca) aiming at demonstrating the economical sustainability of the new process/service with respect to the traditional approach.   
in particular, the goal of the wash&load lcca analysis was to perform a comparative lcca (i.e. life cycle cost analysis) among the functionalised garment washed with state of the art (soa) process (i.e. existing solutions) versus the innovative process/service (i.e. functionalization process) developed within wash&load project framework.   
the existing solution foresees the washing of an already functionalised garment in a washing machine (including the drying phase) up to 50 times and then it has to be disposed in landfill.  
in the functionalization process, instead, the garment to be re-functionalised is inserted into a system which is composed by a washing machine (including the drying phase) having embedded a device that allows to monitor the functionalization of the garment and a sensor (i.e. sensing device) for monitoring the level of functionality on the dried garment after the process. the garment can be treated up to 100 times if it is a white workwear, such as for the food sector, or 150 times if it is a colored workwear washed on 60 â°c. in the performed lcca analysis both cases have been considered.  
the results showed that the economical impacts of the innovative wash&load process are lower than those of the soa process. in fact, even if the utilities and the investment costs are higher than in the soa process, the functionalised garment cost significantly influences the soa process final cost. the consequence is that the final cost associated with the soa washing process is a higher value than those associated with the innovative wash&load washing process.   
  
  
potential impact:  
the final result of the wash&load project is a new concept of a product service system in which ppe is functionalised and monitored during the use life through concepts of renewing of functionalities in the care and maintenance process. the functionality and the process are adjustable to the context of use and to the profile of the user; monitoring can validate the effect of functionalisation and degradation. in order to achieve this objective and to allow the implementation of the new concept, the work carried out by the rtd performer provided to the sme associations involved in the project the following 4 results:  
1) fully scientific characterization of chemical and functional agents   
2) monitoring system to control the functionalization process  
3) reloading process & related guidance   
4) knowledge management platform and life cycle monitoring tool to be exploited by the sme associations and enabling the selection of the most promising candidate solutions for a given functionality and end-use.  
wash&load will have a relevant impact in the textile care sector enabling the transformation of the laundry industry from a washing business, often based on low skills and routine management into a full provider of comprehensive product service systems based on a thorough understanding of the scientific and technical background.  
wash&load expected impact will be twofold. on one side, the project, supporting the introduction of a new business model in the laundry, ppe and functional clothing care sector by shifting the ppe and functional clothing paradigm and replacing the actual fixed life cycle approach with monitoring of functionalities and consequent re-functionalisation, will open new economic perspective for the thousands of smes of the laundry sector and rationalising the whole protective clothing value chain, from functionalisation, to care and final use. this will lead to a saving within the overall value chain, thanks to the prolonged life cycle of the ppe of each garment and their extended use, demanding for higher quality clothing manufactured in eu-27. on the other hand, the wash&load approach, by means of a tracing and monitoring tool through the whole ppe life cycle, will encourage the introduction of new standards and norms for ppe and functional clothing functionalities, ensuring a high level protection of workers with important impact on safety and efficient use of resources.  
the societal impact of the project comprises both an enhancement in workersâ safety thanks to the validated re-functionalisation of workwear and possible benefits for the whole industrial chain from the higher competitiveness of european manufacturers and from the extension of the ppe and functional clothing value chain. the project aimed at a market of 140 million users of personal protective equipment (ppe) in europe. despite the commissionâs great efforts in workersâ health care and accident prevention, in europe there are 4 million accidents on workplace every year, causing the death of 7,400 people. the main objective of the project was to increase protection for workers through an integrated product-process service system. the project focused on a number of business cases for which the technologies developed can be relevant: healthcare, catering and food industry workers (hygiene and skin protection); maintenance services and utilities (soil repellancy). moreover the project could have relevant perspectives for work wears for chemical and manufacturing industries. these sectors combined represent 90% of ppe currently used covering almost 60% of workers in industry. from the point of view of social impact, it is important to underline that setting up an improved new standard for ppe production, as fostered by wash&load initiative, will help european ppe manufacturers in overcoming the competition from low labour cost countries, an issue of utmost importance considering that ppe exports are forecast to grow by 50% in the next few years.   
as far as the dissemination of wash&load is concerned, the goal of communication and dissemination activities performed within the project was to reach the widest impact on european textile care sector, as well as on operational activities to exploit innovative processes and services to improve european competitiveness.  
as such, an efficient overall communication strategy has been set up in order to realize the targeted impact.  
with this respect, the wash&load consortium developed different contents and selected different information channels and events, formulated ad-hoc communication strategies targeting the different industries to be addressed, thus giving qualified answers to all different types of target audiences.  
within this framework, the following criteria have been fulfilled:  
-contents have been carefully selected and implemented in function of the target audience;  
-information channels have been carefully selected in order to best perform in function of target audience and contents.   
project partners have been the communicators with the aim to contact target groups. each partner played a specific role in communication activities.   
as international umbrella association cinet prepared, organized and coordinated execution of the activities ...

# MyWear

Project Acronym: MyWear

programme & topic: FP7-NMP FoF.NMP.2011-4

Most frequent returning words in objectives:

* ('data', 43)
* ('production', 32)
* ('sensors', 25)
* ('platform', 24)
* ('services', 21)
* ('developed', 20)
* ('work', 19)
* ('textile', 18)
* ('integration', 18)
* ('products', 17)
* ('application', 17)
* ('sensor', 17)
* ('system', 16)
* ('order', 15)
* ('project', 14)
* ('shoes', 13)
* ('design', 13)
* ('technologies', 12)
* ('process', 12)
* ('injection', 12)
* ('solutions', 11)
* ('materials', 11)
* ('components', 11)
* ('monitoring', 11)

executive summary:  
nowadays, the full adoption of customer-driven production methodologies and technologies is recognized as of definitive importance for the european manufacturing industry (smes in particular): it is a key strategy to compete in terms of value-added, as cost-based competition is hardly suitable to face the threats posed by emerging countries. specifically, the proposal targets two sectors, sportswear and work-wear, where best opportunities are left only for value added products.  
in addition to this consideration, social phenomena like ageing (19% of eu population is between 50 and 64 years old, and 17% over 65 years old), increase of obese people (35% overweight and 15% obese over the total population), increase of diabetics (8% of the adult population) and major sensitivity towards disabled people (15% over population, ranging from light to severe disabilities) and eco-friendly products, result into challenging specifications for personalized solutions for sport and work, where european manufacturers need methodologies and technologies to get the chance to fully exploit their excellence.  
thus, the project has addressed the production of next generation health, safe and eco-friendly customized work-wear and sports-wear goods for specific target groups, such as elderly, disables, diabetics and obese people, which are of wide and increasing impact in terms of market share for the european industry.  
mywear project aimed at responding to such needs by conceiving an engineering framework - i.e. methods, tools and technologies have been developed, necessary to consumer centred product/services and process innovation - addressing footwear and garments, for specific market segments as work, spare time, and sport.  
pilot implementations in industrial settings, demonstrating feasibility of new concepts and solutions as for shoes and garments, have been developed with reference to two specific market segments: safety/professional for workers and sport.  
  
project context and objectives:  
mywear mission was to sustain the development of a new generation health, safe and ecofriendly customized work-wear and sportswear goods for elderly, disables, diabetics and obese people.   
the following objectives have mainly been addressed:  
new customization process:  
starting from recognizing of the userâs biometric and morphologic properties, and that completing with the mass-customized products; customized yet respecting costs and delivery times typical to industrial processes. this implies to conceive a shop designed to collect user preferences and wishes concerning morphology, functional properties and product use as well as an infrastructure that integrates data collected in the shop with parameters fundamental to driving the mass-customized production processes as well as integrates production and customization data in cad / cam to be more effective and efficient in support the design of customizable products.  
adaptive production system for shoes:  
to develop production machines able to dynamically modify the parameters as a function of the form used (e.g.: change of the injection path of the robot), the implementation and application of different lasts and tools for the same shoe model and the selection of the best insole to use to serve the customer with the best fitting shoes.  
environmental conscious:  
to implement and apply new high performing materials, such as green polymeric materials that have high performance both functionally and environmentally, which will be implemented in sport- and work-wear.   
to develop tools that assist in minimize environmental impact already at the design phase with the purpose of reducing environmental impact of new products by 20% through a improved selection of material and components.  
smart textile and value added services:  
to develop a âtextile intrinsic communication layerâ using textile-based circuits, and specifically designed connection points that can be manufactured as standard in work-wear, sports-wear and shoes, to facilitate the connection of a range of sensors to support individual monitoring. the communication can be for example a full integration in the garmentâs fabric, or welded textile conductors combined with non-intrusive cabling. to instantiate specific services for the single customer considering customerâs health conditions, real-time monitored parameters and historical acquired data and to develop value added services tailored to meet the single customerâs needs  
the project started on december 1st 2011 and ended at november 30th 2014. it aimed at developing innovative process technologies for a new generation of customized, eco-friendly, safe, healthy and smart work wear and sportswear products for elderly, obese, diabetics and disabled people.   
in 3 years of activities different personalized and value added products have then been conceived and developed, capable to meet customers demand, with a specific focus on health, innovation and reduced environmental impact. main categories of the products developed are:   
â¢ work-shoes: safety shoes with a high level of customization, achieved through the flexible combination of the main components like last, sole and insole;  
â¢ work- and sports-wear: clothing with customized fitting and specific sensors for monitoring comfort and performance parameters as well as safety and health conditions.   
the most important investigation areas for r&d activities have been:  
â¢ design customized products using âlightâ biodegradable materials, and through integrated lca methodologies.  
â¢ adaptive production systems and processes for the production of customized goods;  
â¢ technologies for constant remote monitoring of customer biometric parameters;  
â¢ an integrated data management platform, to collect and analyze user data;  
to achieve the my wear project objectives a lean, skilled and complementary partnership has been built, involving 10 partners of 6 different member states. my wear is strongly industry driven, with 7 industrial partners out of 10, 6 of which being smes with leading roles in the project consortium.  
- base protection srl, italy  
- scuola universitaria professionale della svizzera italiana, switzerland  
- consiglio nazionale delle ricerche â istituto di tecnologie industriali e automazione, italy  
- kloeckner desma schuhmaschinen gmbh, germany  
- ohmatex aps, denmark  
- centro tecnologico das industrias textil e do vestuario de portugal, portugal  
- synesis scarl, italy  
- p&r texteis sa, portugal  
- ropardo srl, romania  
 -longhi sa, switzerland  
  
the results of the my wear project have been validated by the setup of integrated industrial demonstration, involving all industrial partners of the project and the addressed target consumers groups.   
an overview of the project structure concerning the technical activities is provided in the following paragraphs:  
work package 1 - âmy-wear reference frameworkâ has mainly defined the guidelines for the other work packages to set the reference framework for the project. the work done in this wp is the basic foundation for all the research activities of the project carried out in parallel in five wps (2-6). wp1 outcomes (especially the validation scenarios) then have also been the innovation and market oriented principles inspiring all the research activities aiming at the full characterization of important product and service properties in relation to some specific consumer categories. the chosen scenarios have been defined considering the chance to be effective in terms of production process improvements and market requirements.   
work package 2 - âdata integration platformâ addressed the designing and the implementation of the platform providing the my-wear system with the following functionalities:  
â¢ integration with a set of health and biometric scanning devices for initial customer data gathering, to drive the production process of personalized goods;  
â¢ efficient management of sensors feedback information, as provided by wp3 development, towards real-time monitoring of specific health parameters;  
â¢ providing remote status monitoring for personalized services (wp6);  
â¢ providing a health status history over time for each person being monitored.  
work package 3 - âtextile intrinsic communication layerâ addressed the design of textile circuitry which has been adapted and integrated in a variety of garment types using standard textile manufacturing and confectioning techniques. four sensor modules using commercially available micro-electronics components (heart rate, respiratory rate, falling and plantar pressure sensors) have been integrated in different garments in order to demonstrate the feasibility of the concept and to facilitate verification of both, the textile platform and connectors, and demonstrating potential encapsulation technologies. as a further demonstration activity, the integration of biometric data collected from the sensors with the data platform was successfully tested.  
work package 4 - âadaptive production systems and processesâ concentrated on the development of a new pilot of automated production line for the manufacturing of customized shoes based on:  
â¢ new robotized cells for flexible upper roughing and cementing. a new software modules has been developed in order to generate consumer specific design customization options. an innovative cam modules has also been realized, aiming at a rapid computing of adequate robot/machine set up and configuration parameters. new mechanisms for âon-the-flyâ automatic piece detection and geometric trajectory recognition have been implemented on a multifunctional robotized roughing/cementing cell, based on vision system and on self-learning algorithms for plc-pc based control and digital cameras.  
â¢ innovative solutions for flexible sole injection. a new self-cleaning mixed head, able to handle up to 8 component/additive valves, has been developed. this technology gives the manufacturer the most degrees of freedom, in fact is able to change the complete mixing ratio between polyol and isocyanate as well as the article parameters (hardness, density, â¦) and the polyurethane components from shot to shot, without interrupting the production cycle. the basic idea is to modify the existing polyurethane chemistry in order to vary the sole properties. by varying the sole properties, the achieved sole can be harder, softer, more or less flexible, better slip resistance etc. this injection solution as well as the robotized cells have been implemented within the industrial plant of base protection for their final validation.  
â¢ new cell for the automated production of customized insole/footbed in shoe models. a new process for integrating customized footbed in shoe model, reducing overall foot bed costs and engineering times by means of fast production techniques, has been designed and developed at prototype level.   
  
work package 5 - âlight biodegradable materials and new integrated lca methodologiesâ mainly investigated on how the use of new eco-friendly materials integrated with specific lca methodologies could improve the performances and the overall value of the products. in this workpackage the following results have been obtained:  
â¢ new protection and reinforcement component in order to be integrated in work wear and sport adapted to specific use, such as heavy workwear and sportswear reinforcement like knee pad inserts in pantsuits.  
â¢ new biodegradable polyurethane for footwear soles.  
â¢ new customized high-performing ether-based polyurethane for particular workplaces (agriculture, food industry, hospital, â¦).  
â¢ new innovative green stain resistance nano technological treatment for fabric.  
â¢ innovative modular lca and eco-design solutions for green products development and assessment in order to limit environmental impact of new work-wear and sportswear.  
work package 6 - âcustomer-centric sensors-enabled value-adding servicesâ mainly designed and developed a set of application services aimed at exploiting the benefit deriving from my-wear integrated solutions. to this scope, an in-depth analysis of three dimensions has been addressed:  
â¢ targeted stakeholders characteristics and requirements;  
â¢ contexts of use;  
â¢ identified, developed and adopted sensors performances and functionalities;  
to design and develop value adding services for targeted stakeholders aimed at exploiting the benefit deriving from my-wear integrated solutions. the development proceeded in the following directions:  
â¢ gathering and description of services functional requirements to present a graphical overview of the detailed functionalities provided by each of the identified product-service solution;  
â¢ non-functional requirements gathered and represented consistently with services functional requirements;  
work package 7 - âindustrial pilots and validation scenariosâ main objectives have been the validation of the my-wear tools, technologies and services as a whole and the promotion of demonstration scenarios where to test my-wear concept and products with reference to the addressed target groups.  
this work-package anticipated, on one hand, the validation of the my-wear tools, technologies and services as a whole and, on the other hand, promoted the development of demonstration scenarios. within this workpackage all the most relevant results developed have been implemented and validated. in particular two main categories of results have been deployed:   
â¢ industrial pilot within a real manufacturing plant (base protection);  
â¢ sample of products addressing the needs of end users belonging to the target groups  
work package 8 - âdissemination, exploitation and new business modelâ main goals have been to promote my-wear results implementation to other sectors to promote the project and to ensure proper dissemination also addressing future potential customers of the developed solutions (esp. ones from the target groups), to support the exploitation of the my-wear research results and of the technologies provided. this is strictly related with the development of a proper and consistent business model.  
work package 9 - was dedicated to all the âproject managementâ activities.  
  
project results:  
1 innovative sportswear and workwear  
1.1 the data integration platform  
a new integration data platform, has been conceived to integrate a wide range of health and biometric devices, capable to gather client data as a base for customer driven production. once the goods are produced and supplied, the platform guarantees efficient management of sensors feedback information, providing remote physiologic life status monitoring in order to enable customized services deployment.  
to summarize, a user can have devices and sensors assigned to him. in order for a sensor to send data (which is stored in the database) it needs to be registered in dip and associated to a user.   
principal system components  
sensors. the possibility to integrate sensors directly with the data integration platform has been excluded in the architecture. the main reasons for rejecting the direct link between sensor and dip are:  
â¢ aim to use the same hw platform in all sensor cases;  
â¢ the gsm-module requires a lot more extra energy;  
â¢ implementation of a gsm-module or the like in each sensor solution will require more physical space (and will add extra weight).  
the sensors controller has to foresee a data buffering mechanism in order to avoid data loss in case of no connection between sensor and master unit. the size and format of the buffer depends hardly on the final use case at each scenario (ex. if the shirt is intended to be used for two hours the buffer size could be designed to hold data equal to 12 minutes (10%)!).  
communication protocol. a protocol has been designed meant to regulate communication between the smartphone application and sensors through the bluetooth channel. the communication protocol foresees a set of commands that allow the smartphone application to access some information about the actual sensor configuration.  
services interaction: these services represent the presentation layer of the architecture (the topmost level of the mywear system). the presentation layer displays information related to such services as real time monitoring, analysis functionalities, etc. it communicates with the application layer by outputting data to the user side application (smartphone applications, desktop application or web site).  
smartphone application: the smartphone has been designed according to the plug-in infrastructure in order to guarantee the scalability of the application: the application has been designed to be extensible with new and different sensors. a sensor plug-in is in charge to manage connection and/or to retrieve raw data coming from sensors via wireless connection. the architecture will define the specifications and the interfaces that allow each sensors system to couple with the internal logics of the smartphone application. the sensor plug-in has to implements a reference interface that foreseen a set of methods able to manage sensor connection and sensor data interacting via a well-defined communication protocol. the sensor plug-in has to be able to interpret data and to translate them into a common data model.  
desktop application: it represents a high service application that allows users to interact with the data integration platform. desktop application is connected with the data integration platform through the dedicated common services.  
web site. it represents a high service application that allows users to interact with the data integration platform. it will provide a set of services customized according to the user is going to use it. web site is connected with the data integration platform through the dedicated common services. dip is online at http://myhealth.host4u.ro   
the data integration platform exposes a set of functionalities that allow external applications such as biometric scanning devices and production planning system to be integrated.   
data coming from scanning devices can be provided to the dip too that will act both as a repository and broker of information. eventually the adaptive cad/cam tools will get those data, elaborate them and drive production of the customized goods. the embedded sensors will also provide data to the dip. those information, together with user data coming from the initial scans, will empower the customer-centric sensors-enabled value-adding services. for these reasons, data coming from biometric scanning devices has to be adapted to the foreseen human data model in order to make them available to the data integration platform, which uses these data for different purposes (to drive the production planning system and to empower the customer-centric sensors-enabled value-adding services).  
  
1.2 textile intrinsic communication layer  
a âtextile intrinsic communication layerâ using textile-based circuitry and especially designed connection points and which facilitates connection of a range of sensors and communications technologies for individual customer specific monitoring solutions, has been designed and developed. this technology is able to collect, manage and transfer to a database a large amount of biometric data managed by the integration data platform (dip, objective nr.1) in order to enable customized services deployment.  
the textile platform is effectively a small independent electronic device with a number of features that enable simple implementation of a variety of wearable sensor solutions in garments and shoes.   
this task focuses on goods manufacturing processes and methods and technologies used in integrating sensors with the aid of the developed textile integration platform.  
the platform comprises a universal interconnection device (uid) which mechanically attaches sensor electronics to a textile surface and which houses microelectronics that enable signal collection and transmission from one or more sensors connected to the device via textile cables. sensors are positioned and fixed into place using well-known mechanical textile attachment technologies (velcro / hook & eye attachment, press-fasteners etc.) and are attached and removed from the textile surface of a garment or shoes together with the uid. varying the length of the textile cables enables optimal positioning of sensors (for best possible signal reception) and electronics (allowing for ergonomic considerations) using the same platform and universal components. universality is further assured, by varying the number of electrical conductors in the textile ribbon to match a variety of sensor scenarios.  
the conductive textile ribbons that interface to a variety of different sensors are considered an integral part of the textile platform. feedback is provided to end-users via a smart phone. transfer of sensor data to a mobile device is facilitated by the textile integration platform.  
  
1.3 customer-centric sensors-enabled value-adding platform services  
implementation of ânew innovative servicesâ related to my-wear representative target groups.  
data acquired from the user are managed by the sensor unit and transmitted wirelessly to a master unit (smart phone) forwarding data to the data integration platform. customer data are stored in dipâs database and made reusable for external applications.  
starting from the collection of outcomes of other tasks, the activities of the task required an integrated in-depth analysis and evaluation of each target groupâs needs and requirements according to the context of the product used (e.g. t-shirt, shoes, etc.), data to be monitored and identified sensors, taking into account different scenarios.   
the outcome of this analysis is summarized with the identification and description of particular smart service application as practical benefits for the selected representative target groups.  
selected test cases:   
a. obese and diabetics  
shoes with plantar pressure sensors for continuous monitoring of body weight evolution and overall weight distribution (to avoid irreversible changes on the userâs musculoskeletal structure)  
b. elderly   
t-shirt with flexible dielectric electro-active polymers (deap) for monitoring of respiratory rate related to progressive degenerative condition of the respiratory system (emphysema) in older people due to aging, characterized by shortness of breath and an inability to tolerate physical exertion.  
c. elderly   
t-shirt with fall detection and heart rate sensors for continuous monitoring of fall events with possibility to control vital activities through heart rate and geographic localization (gps tracking).  
  
2 adaptive production systems and processes  
new adaptive production systems and processes for the realization of customized goods, which require both fast adaptation to customer requirements and synchronization of different manufacturing operations for the fully automated manufacturing of customized products through innovative operating machines and robotic applications, have been developed. the production phase can now benefit of specific innovations in order to conjugate personalization and fast production with cost aspects.  
2.1 robot cell for roughing and cementing   
this development provided a new robot cell for flexible upper roughing/cementing as well as a sole treatment cell, increasing product quality and reducing processing time avoiding manual intervention. the system is composed of the following main elements  
1. main operator   
2. shelfs for raw materials  
3. manual feeding station   
4. upper treatment robot  
5. bottom grinding station  
6. side roughing station  
7. cleaning dust station  
8. spraying cement  
9. sole cell   
10. manualy drying system   
11. activation station  
12. pressing station   
13. delasting station  
14. shelf for ready shoes   
15. operation panel   
16. cabinet for robot   
17. main cabinet   
18. exhaust station   
19. glue reservoir  
20. safety fences   
  
2.1.1 interface cad/cam  
traditionally the programmer / operator need approx. 20 to 60 min to create new robot programs for one style, as described before. one of the requirements is that an individual efficient sample production should be possible. the production of 30 pairs per hour is also required. it is not possible to teach or program all different upper material at the production machinery. therefore one of the most important points in this wp 4 is the interfacing between the cad and cam systems with the gained data from the adaptive tool coming from t 4.1.  
2.1.2 prototypes developed  
the main working stations of the cell are a robotized upper treatments cell and a sole spraying cell  
the core technology of this cell is able to compensate the given tolerances in the unit soles. the programming of the robot paths is given automatically by the integrated scanner system with adapted software.   
furthermore, the following additional functions have been developed:  
â¢ article navigation for elementary setups   
â¢ further calibration methods to synchronize digitizing and spraying pattern  
â¢ definition of limitations for treatment  
the integrated version of delivered prototypes have been installed as demonstration pilot plant in base protection.   
  
2.2. new solution supporting flexible sole injection   
this is a new injection process technology for the flexible sole injection customized to the particular needs of a foot, to conjugate savings in customization costs and reduction of setup times, thus enabling a more efficient accommodation of changes in the batch composition and reduced processing time for soling machine.  
as the chemical composition of the polyurethane in the state of the art systems is static, since it is given by the system setup and no flexible changes are possible. due to the fact that according to main mywear requirements for footwear a variable sole injection is essential, there is a need for a new controlling approach for a flexible set up able to provide different formulations by adjusting the additiveâs independently.  
for this reason, a new additive cart has been developed and built.   
the additive carts carries a selected additive, like a blowing agent, crosslinker or uv stabilizer. the cart is equipped with a double jacket material tank, which is able to be temperature controlled and pressurized. furthermore, there is the high accurate dosing gear pump with a very low pulsation, responsible for the precise metering of the additive.   
an additive valve has been especially designed for low viscosity fluids with a standard diameter of the valve of 0.1 mm.  
the additive valve can be opened or closed pneumatically. since the injection of the additive is a key factor for the correct mixing, the control must observe the introduction of the additive. therefore, the opening stroke as well as the injection pressure is measured and logged into a file.  
the prototype of this system was developed and installed as demonstration pilot for the validation session performed in base protection.  
2.2.1 software application  
the existing machine software has been adapted in order to fulfil the overall control require by the new process technology. the article will be separated into three main sections maximum, where each section properties can be adjusted individually to the beforehand determined injection parameters   
there will an overlapping of the three different liquid pu formulations at the injection process, but it is estimated that this circumstance creates a more comfort situation for the human foot, since there will be no choppy edges.  
the following injection parameters have to be adjustable within each of the three sections independently from each other:  
â¢ throughput of the components   
â¢ throughput of the additives  
â¢ mixing ratio of the components polyol and isocyanate  
â¢ percentage of the additive related to polyol within each section  
  
2.3 machine for integration of customized footbed in shoe models   
starting point for this objective was the european norm constraints and performance over the final work shoe product are posed by en standards (en iso 20345). the final foot bed customization will have to be compliant with:  
â¢ dimensional constraints   
â¢ type of shoe construction  
â¢ technical features  
â¢ delivery times and costs.   
the aim of this development has been to elaborate, design and prototype a new process/machine for providing customized foot bed, reducing overall foot-bed costs and engineering times by means of fast production techniques.   
at the end of the project a prototype of machine for production of customized footbeds has been developed having the following principal features:  
machine features:  
â¢ process typology: 1 shot milling using multi tool approach   
â¢ milling tools: 10mm diam. spherical tool   
â¢ process quality: max step over (45â°) 4mm ã  max distance between 2 milling tools for a global 1 mm surface roughness   
â¢ material type: ethyl vinil acetate (eva) with variable density   
â¢ raw block dimensions (lxwxh): 250x300x30mm   
â¢ working time: 5/7 min./pz.  
  
technical features  
â¢ mechanical   
 o no cooling system   
 o no lubrication system   
â¢ open linux rtai control  
â¢ rhinoceros cam plugin   
the prototype is installed within the itia-cnr r&d laboratory of vigevano.   
  
3 light biodegradable materials and new integrated lca methodologies  
3.1 high performing biodegradable components for work wear and sport wear   
a new protective knee pad insert has been developed in order to be integrated in work wear, especially in pantsuits and jackets. such element is based on innovative plastic materials integrating traditional properties, such as resistance to torsion, and resistance to shock. moreover, innovative properties such as lightness, elasticity and biodegradation are integrated in new materials.   
the basic concept then was to develop an advanced design for multifunctional products for promoting safety and comfort. different examples available in the nature of articulated protective segments (bony or cartilaginous) have been considered.  
beside the preliminary conceptual modeling phase the engineering of the most promising models has been carried out until the realization of fully personalized prototypes, that has been approached through an innovative manufacturing procedure: 3d printing.  
the process solutions identified and tested together with new materials, being lighter and adaptable to different shape, can potentially be used in clothing sector thus promoting safety and comfort.  
  
3.2 innovative modular lca and eco-design solutions for green products development and assessment  
state of the art.  
42 eco-design examples in the footwear sector has been tracked in the last two years (2012-2013) most design actions are based on material design rather than on life cycle tracking. standard approaches in eco-design and environmental footprint tracking still miss to be applied.  
102 eco-labels which are applicable to the textile and footwear companies has been tracked. most of them are not referred to the whole life cycle but on specific improvements. most of them falls in type i and ii iso category which means they do not report environmental quantities to customer.  
general aim of the task is not just the assessment of the final environmental footprint but also a support during the design phase.   
moreover, the lca has had a real assessment of the environmental impact due to complex footwear and an effective outcome for the smes and research community.  
the proposed methodology  
this specific methodologies aims at supporting the analysis of the environmental profiles of different materials and components in order to limit environmental impact of new work-wear and sportswear. such methodologies could be integrated in design and plm tools for shoe and clothing products.  
the link with the production cad can enable a comparison of eco-efficient solution directly within the initial design of the footwear.   
last implementation  
introduction of functions for environmental impact assessment within cad-pdm tools by  
- separate lca studies on specific components  
- adaptation algorithms of environmental profiles to physical features  
- link with update eco labelling framework  
  
4 industrial pilots and validation scenarios  
4.1 industrial pilot for the automatic production of customized, healthy and green safety shoes  
4.1.1 an automatic pilot production line has been installed at base protection facilities, for the manufacturing of customised, green, safe, healthy and smart work shoes for the addressed target groups.   
the industrial pilot for the automatic production ...

# SMILEY

Project Acronym: SMILEY

programme & topic: FP7-NMP NMP.2012.1.4-2

Most frequent returning words in objectives:

* ('devices', 33)
* ('process', 31)
* ('miao', 28)
* ('processes', 22)
* ('properties', 21)
* ('mineralization', 15)
* ('dental', 15)
* ('scaffolds', 14)
* ('collagen', 13)
* ('fibres', 13)
* ('developed', 13)
* ('filters', 12)
* ('regeneration', 11)
* ('tissues', 11)
* ('polymers', 11)
* ('tooth', 11)
* ('development', 11)
* ('materials', 11)
* ('bone', 10)
* ('applications', 10)
* ('production', 10)
* ('synthesis', 10)
* ('constructs', 10)
* ('cells', 10)

executive summary:  
smiley project intended to apply a bio-inspired assembling/mineralization process (miao) to a wide number of macromolecular matrices with the purpose to generate new smart devices with application in several high-impact fields. the process was previously well assessed on collagen molecules: under physiological conditions and by ph variation, collagen fibrils assemble into thicker fibres and undergo mineralization with biomimetic apatite nanophases, thus generating fibrous scaffolds for bone and osteochondral regeneration with outstanding mimicry of the host tissues, and high regenerative ability. the miao process is entirely driven by the information and control mechanisms inherent in the molecular structure of collagen and by the features of biomimetic apatites that nucleate in specific molecular loci present in the collagen structure, thus reproducing the biological phenomena of the formation and mineralization of hard connective tissues in mammals. smiley intended to translate this process towards wider applications, by exploiting the ability of natural polymers and fibres to expose functional groups enhancing chemical, or physical, mutual interaction. this opens to the generation of macromolecular composite matrices where bio-inspired mineralization may occur. in this respect, apatites are a family of minerals exhibiting a variety of properties, as induced by the ions present in its lattice. therefore smiley aimed to direct and tailor miao processes to the generation of hybrid composites with designed properties for multiple, high impact applications in the environmental, health and safety fields. particularly, smiley aimed to response to relevant socio-economic needs such as: i) the filtration of nanoparticles in critical size range, ii) the regeneration of dental tissues such as periodontium and dentine and, iii) the production of energy by wearable, low cost devices. smiley focused its activity in the selection and modification of natural polymers and fibres to create macromolecular matrices with designed properties. the association of polymers with different hydrophilic ability enabled the synthesis of 3d constructs with ability to recover and manage the moisture, for application in healthcare as heat moisture exchanger devices (hme). bio-inspired mineralization with apatite phases was carried out in compliance with the requirements for the final devices. therefore, biomimetic scaffolds mimicking the whole periodontium and the dentine were developed and biologically tested, thus opening to new possible solutions for regeneration of the whole tooth. a new apatite phase with photoelectronic properties was developed and firstly nucleated onto natural fibres to obtain photo-active fibrous elements that were incorporated into flexible devices able to produce energy. iron-substituted hydroxyapatite nanophase was developed and tested in all the three application lines to exploit its properties, by means of hyperthermia, possibly activating thermophoretic effects in filters, cell stimulation towards enhanced bone formation, and possible electronic properties. the miao processes yielding the three different devices were analysed to draw preliminary roadmaps for the development of flexible production lines for the manufacturing of smart devices for mass applications in relevant socio-economic fields.  
project context and objectives:  
the project smiley pursue the development of new materials to solve relevant socio-economic needs, as following described.  
â¢smart filtering devices.   
in the last decade the contamination by airborne particles has become a crucial aspect in human health due to recent research and findings that point out potential and/or effective physical damage. the harmfulness of contaminating media is strongly increased in the case of nano-sized particles, where it is related to the particle size, specific surface area and surface activity. it has been shown that cells and organs can give a toxic response even to apparently non-toxic substances, when they are exposed to a sufficient dose in the nanometric size range. filtration is the simplest and most common method for particle removal from air (or other gases) and it is used in a variety of applications. the filtering mechanism can be simply mechanic (commonly by using glass fibres) or assisted by permanent (electret filters) or activated electric fields (electrically enhanced filter, eef). the most important characteristics of air filters are the removal efficiency and flow resistance or pressure drop. none of the known mechanisms for particle interception is dominant in the intermediate region (typically ranging between 30 and 500 nm), commonly called the most penetrating particle size (mpps). on the basis of recent results, efficient filtering devices for personal protection against nanopowders generated in battlefields can be obtained by miao processes applied to gelatine-based matrices bio-mineralized with apatite nano-particles. this preliminary result represents a conceptual pin for further development of innovative hybrid filtering devices whose performance can be tailored and directed by flexible adjustment of the synthesis parameters.   
hme filters are used in artificial ventilation to humidify and warm the cold and dry gases from the pulmonary ventilator. such filters work as heat exchangers, which accumulate the heat delivered from the patient breath and transfer it in the inhalation phase. these filters accumulate the moisture that arise from the breath and then condensate because of the reduction of the external temperature and afterwards the moisture will be transferred during inhalation. these filters work at room temperature and can humidify and heat the inlet gas of a few degrees. generally hme filters are used in anaesthesia and for short treatments, while in intensive therapy (long treatment) the use of steam heated water are preferred, because they are better in terms of performance. however they are more complicated (large dead space variables), more subjects to bacteriological pollution and have higher costs. in europe alone the use of hme filters is estimated as 30 million pieces. the possibility of heating the filter with electromagnetic fields would allow a greater functionality of the filter in terms of heat and hygrometric exchange and with an instant efficiency (the latency of a not heated filter is equal to about one hour). a further function of hme filters, in addition to the properties described above, concerns the antibacterial and antiviral filtering capabilities.  
â¢ scaffolds for regeneration of dental tissues  
like bone, tooth regeneration is of particular relevance to the field of regenerative medicine and elicits a huge public interest. tooth loss is a common result of a variety of oral diseases due to physiological causes, including dental caries, periodontal disease, trauma, genetic disorders and aging, and can lead to physical and mental suffering that markedly lower the individualâs quality of life. a tooth is a complex organ that is composed of calcified tissues (enamel, dentin and cementum), and soft connective tissues (the dental pulp and the periodontal ligaments) in which blood vessels and nerves are protected. therefore, regenerating a whole tooth for clinical tooth replacement is considered to be a remarkable scientific objective and an outstanding goal. human teeth form following a complex cascade of biological events that involve several cell lines. therefore, dental scaffolds should exhibit high compositional and structural mimicry of the different dental tissues.   
to date, approaches to tooth regeneration are still at their infancy and face many challenges. current processes are mainly based on biomimetic calcium phosphate coatings used to modify dental titanium implants. more complex approaches have been used to engineer structure containing layers which are targeted at the regeneration of different dental tissues, or even tooth root engineering using tissue from postnatal teeth. however, these approaches still have not provided ecm-like scaffolds which can drive cell behaviour towards tissue regeneration. in this respect, the understanding of the bio-mineralization principles governing tooth formation represents a pivotal step in designing regenerative biomaterials. it is becoming increasingly apparent that the miao processes at the basis of the formation of periodontal bone, cementum and dentin are quite similar to those occurring in bone synthesis. in this respect, in 2001 the proposers (cnr-istec) developed a laboratory procedure which closely resembles the miao process naturally occurring in the formation of new bone tissue and which led to highly regenerative bone scaffolds. upon controlled variation of the mineralization degree, cnr-istec also obtained morphologically and compositionally graded scaffold that, due to its remarkable mimesis with the biological tissues of the articular region (e.g.: subchondral bone, mineralized and hyaline cartilage) was able to trigger the specific cell phenotype of each different tissue and completely regenerate osteochondral defects. the success of these devices led to a number of international patents and commercialized biomedical devices. more recently, the proposers (cnr-istec) developed and patented a process for the synthesis of ha nanopowders with intrinsic super-paramagnetic properties thanks to a chemically and positionally controlled doping of ha lattice with fe2+/fe3+ ions. these are promising for the development of biomimetic scaffolds with increased regenerative potential. the recognized success of biomimetic medical devices obtained by miao processes suggests that a viable and promising approach for tooth regeneration can be the successful fabrication of ecm-like structures which mimic different tooth areas, together with adequate tissue engineering strategies.  
â¢ fibrous photovoltaics for energy production  
with the increasing concern about environmental issues and growing energy demands, solar energy is considered the most attractive, long term energy source and solar cells the major candidate for its harnessing. photovoltaics are in fact the most advanced way of providing electricity in the absence of a main supply. the widely used silicon based (mono or polycrystalline) cells are rigid, and are therefore not suitable for curved surfaces and have to be rightly oriented towards the sun in order to assure the desired efficiency. integration of solar cells into textile would benefit numerous fields including clothing, transportation and civil engineering. further, with the rise of portable electronic devices, fabric integrated photovoltaic (fip) can potentially power most mobile electronics (e.g.: mobile phones, tablets, mp3-players). there are limited scientific studies and very few commercial applications of fip. from the viewpoint of the customer, the fip should be fully conformable, offer a universal socket for the different devices, and should be well integrated with the specific design of the garments considered. for this reason, research has been focused on developing fibre-based solar cells. when coupled with the commodity scale of fibre and textile technology, fibre-based photovoltaic devices could help to realize cost-effective, scalable solar energy harvesting. particularly, dye-sensitized solar cells (dsscs) could offer interesting opportunities in terms of end user satisfaction. the core of the dssc cell is the semiconductor photo-anode that should exhibit: fast electron injection and separation, slow electron recombination, excellent electron transport, high surface area and outstanding light collection. besides the conventional tio2 and zno, doped apatites have recently attracted attention for their photo-electrochemical  
properties, also thanks to recent results showing that the band gap of apatites can be easily tuned according to the amount of specific ions introduced into the crystal structure.  
some attempts have been made to produce flexible dssc fibres, however the obtained substrates did not offer the possibility of integration into garments using the textile technology. miao processes are therefore promising as a new approach for synthesis of new flexible photovoltaics for smart textiles.  
  
in respect to the above described issues, smiley aimed to develop and apply a "bottom-up" approach to build nano-structured devices with smart, multi-functional properties, by using abundant and environmentally safe raw materials, such as natural polymers and fibres. to this aim, nature was used as the inspiration for the development of an ensemble of miao processes, which was controlled to first generate elementary nano-sized building blocks, and then to direct their assembly towards the final devices, in particular:  
i) smart filtering devices   
a proper implementation and direction of miao processes provided fibrous constructs with tailored pore size, geometry and organization as well as a high degree of mineralization. macromolecular templates with optimized properties of microstructure, porosity, physical stability in relevant environment and efficiency, were developed and engineered to create fibrous structures with ability of filtration and management of the moisture. fibrous filters were finally developed as heat moisture exchangers (hme), which can be used for patient external ventilation, to humidify cold and dry gases coming from the pulmonary ventilator.  
ii) scaffolds for dental repair and regeneration  
miao process in association with other forming techniques, was directed to the development of hybrid mineralized constructs mimicking alveolar bone, periodontal ligament and cementum. the designed constructs, exhibiting physico-chemical-microstructural features mimicking different human mineralized tissues, were also developed in association with superparamagnetic feha phase to obtain ability of remote activation by magnetic fields. hybrid mineralized scaffolds with tubular porosity mimicking dentin tissue were obtained and tested. stability tests and preliminary biologic analysis confirmed the potential of the new materials to be used as dental scaffolds.  
iii) fibre-based photovoltaic devices  
bio-inspired miao processes was carried out in association with various natural fibres, resulting in heterogeneous nucleation of new apatite phases with photovoltaic properties, synthesized and developed in the project. photoactive components were obtained also by dye staining in mineral crystals. the setup and optimization of the manufacturing process, in compliance with the features of miao process, led to development of photovoltaic fabrics replicating, at the fibre level, the structure of third generation solar cells flexible (so-called dye sensitized solar cells). the potential of integration of photovoltaic devices in fabrics will generate outstanding advantages in all fabric-related applications, for a convenient form of off-grid energy generation.  
the success in the direction and application of miao-based processes to the development of different devices with designed properties is a first step for the establishment of a technological platform based on highly reproducible, scalable and cost-effective processes for the synthesis of multi-functional devices with huge economic, environmental and social impact.  
the development of smiley required a multi-disciplinary approach, thus a deep trans-national cooperation and synergy between european public research centres and universities endowed with experience in material science (cnr-istec/isac, fsu jena, iwnirz) and basic knowledge on template-mediated mineralization processes (uoy, univleeds), as well as private companies expert in biomaterials (fincer) and filtering systems (pollution), and in the assessment of biological characteristics of the obtained devices (lemi).  
project results:  
wp1. selection and modification of natural polymers/fibers  
  
objectives   
- to provide specifications of the most relevant chemico-physical, morphological and functional properties that 3-d constructs obtained by miao process should exhibit in order to function as filtering devices for nanoparticles, scaffolds for dental regeneration or photovoltaic fabrics respectively.  
- to select suitable natural polymers and fibres, which will be pre-processed, when necessary, prior to applying miao processes. blends of the obtained raw or pre-processed materials will be achieved to obtain composite polymeric fibrous matrices.  
  
participants: iwnirz, cnr, univleeds, fsu jena, fincer, lemi, uoy, pollution  
progress of wp1  
blends of natural polymers (i.e. collagen, chitosan, alginate, gelatin, bnc) were studied with the aim to improve chemical and/or mechanical stability of the developed prototype and to dispose of polymeric matrices suitable for miao process. multi-component stable solutions and suspensions were prepared, then the parameters regulating fibration/co-precipitation and assembling of polymers such as temperature, ph, concentration, were setup. blends stability was optimised in terms, not only of chemical composition, but also of chemical reticulation and drying process. besides the blends based on natural polymers, less hydrophilic polymers like pcl, plla, pla/phb resistant to water/humidity, relevant in the case of filtering system, was also investigated. the key goal is to build organized 3d polymeric constructs endowed with the suitable chemical-physical, structural and ultra-structural features inducing the specific functionalities required for each of the tree different application involved in the project. a clearer definition of the relevant raw materials and related modifications for the different final devices was made.   
in particular:  
filtering materials  
chitosan and gelatin were selected on the basis of their hydrophobic and hydrophilic properties, suitable to achieve devices for moisture capturing and exchange. alginate, wool, plla, pcl/phb and bnc were selected as base materials for their potential to create macro- and micro-structured network with organized porosity suitable to capture the nanoparticles.   
dental scaffolds  
to achieve suitable mimicking of cement, periodontal ligament and alveolar bone tissues, collagen and bacterial nano-cellulose were selected as base materials. to mimic the complex structure of the dentin alginate and gelatin were choose. these raw materials also offer the possibility of forming complex structures (e.g. tubules, membranes) so to make easier the development of tooth-mimicking constructs.  
new dsscs  
following the activity carried out in the first eighteen months, wool and flax were selected as the most promising natural fibres to drive miao processes. moreover, wool and flax resulted suitable to be coated by a conductive polypyrrole layer that results able to drive biomineralization with mineral phases endowed with the required band-gap value (selected in wp6: titanium doped hydroxyapatite and titanium dioxide).  
  
  
wp2. hybrid composites by miao process: activation of control mechanism mediating biomineralization  
start month: 1 end month: 24  
  
objective  
to synthesize hybrid mineralized composites by controlled fibration of different organic polymers / fibres, acting as templates for heterogeneous nucleation of various mineral phases. a continuous feedback between the synthesis conditions and the assessed properties of the hybrid composites will provide a comprehensive picture of the mechanisms controlling assembling, organization and biomineralization processes as well as the chemico-physical, structural and ultra-structural features of the 3-d constructs that determine specific functionality.  
  
participants: cnr, univleeds, fsu jena, iwnirz, uoy  
progress of wp2  
â¢ bio-inspired mineralization of several bio-polymeric fibrous composites based on silk, fibroin, cellulose acetate, pla/phb copolymers, acetylcellulose and bacterial nanocellulose were investigated, for the heterogeneous nucleation of calcite crystals, by using different habit modifiers to force inorganic crystals to nucleate at fibres surface and to produce adherent, uniform coatings (univleeds). also, the crystallization of apatite in defined conditions of confinement, also in presence of different agents such as glycine, glutamine and citrate ions, was investigated (univleds, cnr).  
â¢ the heterogeneous nucleation of substituted apatites was tested on collagen-based blends and gelatine matrices. in particular, the crystallization of magnesium- and iron-substituted apatite nanoparticles was achieved in different conditions, i.e. different apatite/collagen ratios, to investigate the potential to create fibrous constructs with different mineralization extents for dental reconstruction (cnr).  
â¢ calcium carbonate crystals were modified by incorporation of organic molecules to generate new dyes for use in dsscs. the use of amino-acids to improve the incorporation of molecule was investigated and some of the mechanisms related to the phenomenon were elucidated.  
cross-linking procedures were investigated and applied to collagen, gelatin, chitosan, alginate and blends of them to impart defined morphologies and chemic-physical properties.  
directional freezing into 2d and 3d patterns was investigated on different polymeric matrices, resulting in the achievement of constructs with defined porosity and promising to create pre-defined 3d ordering into a gel. heterogeneous nucleation of mineral phases exhibiting photo-electronic properties (e.g. ti/zn apatitic-like phases, tio2, zno) were setup on natural fibers to produce new generation dye-sensitized solar cells.  
â¢ the synthesis of new inorganic dyes was investigated by exploring the mechanisms driving incorporation within calcite crystals by mediation of suitable amino acids at definite ph (univleeds). the observed correlation between the ph of the reaction mixture and the level of dye occlusion supported the previously proposed mechanism of dye incorporation which involved the formation of intramolecular interactions between both organic species, and the dependence of the protonation of amino acids by ph. it was also shown that the relative charge of supporting amino acids can be used as a reference value to predict which amino acids are going to enable dyes occlusion at any given conditions. further, by studies of polarized light it has been shown how some organic dyes orient preferentially along specific crystal directions.   
zno-tio2 composite nanopowders (nps) were investigated and prepared by laser co-vaporization (colava) method to develop photoelectric active ceramic semiconductors with minimization of photo-generated electron/hole pairs recombination (fsuj). these raw powder mixtures were vaporized into plasma in the intense focus of a pulsed co2 laser beam in a continuously flowing process gas (air) at atmospheric pressure. the new materials showed increased activity due to intra- or interparticle phase compositions and phase distributions. both could result in heterojunction effects which increase the lifetime of photo-generated free charge carriers. in consideration of these result, cost efficiency, biological and chemical resistance, a high oxidation potential, and a long-term stability against photo- and chemical corrosion, laser co-vaporized zno-tio2 composite nanopowders (nps) are ideal candidates for applications in the environmental sector as well as for immobilization in and photoelectric activation of nano-fibrillar networks or textile fabrics.  
the transition of amorphous calcium phosphate (acp) to ha was studied by tem (istec-cnr) to study the process of infiltration and mineralization of microfibers such as collagen. the role of the citrate in the stabilization of acp was studied in details also by raman microscopy and transmission electron microscopy and electron diffraction on acp/citrate samples as a function of time. the occurrence of distinct diffraction rings at scattering vectors related to the {002} and {211} lattice planes of hap was firstly observed, then after approx. 5 days the transition to hap is complete.   
â¢ fe2o3 silica coated lava nanoparticles (fsl) with a composition of 60 %v/v maghemite and 40 %v/v silica was dispersed in culture media to incorporate in bacterial nanocellulose (bnc) fleeces (fsuj). stirring procedures were adopted to significantly enhance the bnc production and improve homogeneity in the bnc network. this should lead to 3-d nanofibrous cellulose hydro-gel hybrid materials with adjustable magnetic properties. although, the achievable saturation magnetization is directly connected to the stability of the dispersion in the culture medium, and the quantity of incorporated particles, both are on an upper limit of 2 g/l.   
â¢ miao processes were developed (istec-cnr) to obtain hybrid superparamagnetic composites suitable for moisture exchange and filtering applications (hme devices). due to its ability to act as a habit modifier in mineralisation processes, by virtue of its strong affinity with divalent ions, alginate was used as a matrix to generate cross-linked 3d structures with resistance to water dissolution but high hydrophilic character. 3d ordered structures composed of alginate xerogels mineralised with feha were proven to be suitable internal components for filtration-hme systems, particularly to be used as the core part of hme filters and embedded within hard gelatine/chitosan blend, optimized in wp1. preliminary tests showed a good integration between these two components and confirmed the stability of the magnetic internal part. this suspension was further freeze-dried to obtain a superparamagnetic composite material that could be finally integrated into the final hme filter.  
â¢ mineralization of type i collagen was optimized to generate a superparamagnetic material with high mimicry of the structure of alveolar bones (istec-cnr). suitable 3d scaffolds were obtained and optimized by means of composition and physical stability. the tuning of the porosity extent and pore organization ideally favoring cell adhesion and proliferation and scaffold vascularization was obtained by controlled freeze-drying processes. in order to develop a dentine-mimicking scaffold endowed with magnetic properties, the miao process was set up in the presence of gelatin, as a mineralized matrix that was then mixed with an alginate matrix in order to obtain the channel-like morphology typical of dentine.   
mineralization procedures for fibres addressed to dye-sensitized solar cells (dsscs) were developed (istec-cnr). polypyrrole (ppy) coated fiber composites were produced by in situ chemical oxidative polymerization of pyrrole on the surface of carded wool at room temperature. miao process was applied to obtain a layer of hydroxyapatite (ha) and titanium doped hydroxyapatite (ti-ha), with a composition of 15 mol%, with improved coating uniformity. pyro-glutamic acid was used to promote ha and ti-ha nucleation on its surface. a complete covering by the mineral phase was obtained, at high calcium/phosphate concentration and thanks to the use of pyroglutamic acid.   
â¢ the systematic changes in the molecular and mechanical properties of the collagen microfibers following mineralization were investigated by raman microscopy (uoy). it was shown that the proline raman band shifts as a function of stress only in the presence of mineral phases. combination of experimental raman data and the modeling results therefore indicate a significant impact of the degree of mineralization on the molecular configuration of the proline. at this point it might be speculated that the role of mineralization could be to inhibit the possible stress-response of the collagen via the reduced cross-linking potential of the proline, where this would lead to an increased response of the proline to stress.   
  
wp3. set up of process repeatability and scalability at pilot plant  
start month: 18 end month: 36  
  
objective  
wp3 aims to assess the translatability of the project results toward industrial applications in terms of production and investments, quality, regulatory requirements, and commercial opportunity.  
the new fabrication concepts will be transferred to develop flexible production lines producing new custom-made multi-functional products with high level of automation and high product quality.  
  
participants: fincer, pollution, cnr, univleeds, fsuj, iwnirz, lemi  
  
progress of wp3  
the feasibility of modifying the miao process in a flexible manner, and of directing the process in a repeatable manner to develop the three different devices envisaged in smiley project was thoroughly investigated. a roadmap for development of flexible production lines based on miao processes was traced. the miao process was flexibly directed to the pilot scale up of the final devices, thus reaching different level of advance. specific parameters for quality assurance and control in the three production lines were defined, together with relevant standards of protocol.  
the main steps toward the product commercialization and dissemination were identified, in respect to the features of the different applications. therefore, some of the reported aspects are related to products designated to the medical field and the related patient health preservation. the process validation and the process scale-up are a common point within the project therefore the intersection among the different processes were defined, to find the common steps. on the other hand, biocompatibility has to be structured taking into account the application and classification of the device, talking about medical devices. the biocompatibility is correlated to the product and iso 10993 has to be analyzed and followed in order to define the test and path necessary for the application and classification.  
analyzing the whole process and considering the overlapping phases, in the center we can fix the miao process related to the biomineralization of natural fibers. in detail, the miao process is applied to the dental field with the biomineralization of gelatin for the dentinal scaffold and collagen for the periodontal substitute prototype.  
within the filtering application the wool seems to be the best candidate, also applied for the dssfs devices which has also tried a proof of concept with flax.  
the miao process is always characterized by an acid-basic reaction which allows the hydroxyapatite particles to be nucleated on the natural fibers.   
collagen and gelatin need a precipitation of their acidic solution within the basic one, while the wool and flax are dipped and impregnated in the basic solution and then immersed in the acidic one.  
what is real in common comparing all the processes within the scale-up and validation phases is the freeze-drying and packaging steps.   
hmes device  
concerning the industrialization of the natural polymers to be used as hmes, the critical parameters which need to be monitored in the lab-scale production were accurately defined. pilot-scale tests were carried out in 2015, to setup and gather optimized protocols to obtain homogeneity and reproducibility of the freeze drying process, as well as the best shape and size for the containers.   
dental scaffolds   
engineering aspects of process scale-up have been analyzed in order to assure a reliable and practical method of manufacture from laboratory into industrial scale facilities. a pilot plant has been designed to produce trial lot quantities of material for preclinical characterization. the pilot plant has been useful to understand critical process parameters and lead to the definition of standard operation procedures for batch production of material and relative quality controls. test data demonstrate that product specification have been maintained. tga, icp analysis, and swelling test data showed the conformity of the values and the repeatability of the manufacturing process taking into account all the scale-up activities developed within wp3.  
fibrous photovoltaic devices  
the synthesis of blue, dyed, zinc oxide crystals using the described methodology is the first successful example of organic dye incorporation within inorganic mineral that took place in the microwave radiation field. it is considered to be a breakthrough, as it enables other researchers to produce high quantities of artificially coloured, semiconducting inorganic solids. the main success of the work came from developing a system that allowed for the synthesis of dye-doped zinc oxide with microwave heating, rather than conventional. this was significant as the reactions were completed at times as short as 1 minute, compared to 30 m ...

# 3D-LIGHTTRANS

Project Acronym: 3D-LIGHTTRANS

programme & topic: FP7-NMP NMP-2010-3.4-1

Most frequent returning words in objectives:

* ('yarn', 45)
* ('manufacturing', 41)
* ('process', 39)
* ('fabric', 33)
* ('fabrics', 30)
* ('hybrid', 27)
* ('simulation', 24)
* ('3d-lighttrans', 21)
* ('results', 18)
* ('processes', 17)
* ('textile', 15)
* ('yarns', 15)
* ('fibre', 14)
* ('project', 13)
* ('reinforcement', 13)
* ('material', 13)
* ('warp', 13)
* ('matrix', 12)
* ('properties', 12)
* ('part', 12)
* ('analysis', 12)
* ('technology', 12)
* ('order', 12)
* ('composites', 11)

executive summary:  
2. publishable summary   
the goal of 3d-lighttrans project was to provide ground-breaking, highly flexible and adaptable low-cost technologies for manufacturing of 3d textile reinforced plastic composites, including innovative approaches for the individual processes and its integration in complete manufacturing chains, which enables to shift them from its current position in cost intensive, small series niche markets, to broadly extended mass product applications, not only in transportation, but also in other key sectors, like health and leisure.  
  
the main process steps are:  
1. hybrid yarn manufacturing. hybrid yarn, composed of reinforcement material and thermoplastic matrix, is produced using a flexible and reliable manufacturing process. the hybrid yarn can be realised with customised properties and different compositions.   
2. weaving. the hybrid yarn is woven to create multifunctional textile preforms, such as double shell or spacer fabrics, and multilayer fabrics, with fibre architecture suited to the desired deep draped form of the final part.   
3. draping and fixation. the draping of the locally pre-fixed textile into the desired final 3d-form is performed in a fully automated way (avoiding the lower efficiency and reproducibility of customary manual draping).   
4. storage and transport of fixed pre-forms. in the case of thermoforming taking place at a different places or in a later time (draping and fixation performed in an intermediate, dummy tool), the pre-forms can be safely stored and transported in its fixed final geometry at room temperature.   
5. thermoforming. the final composite part is consolidated by a fast and efficient thermoforming process. neither infiltration nor injections of the matrix material are required, as the thermoplastic matrix is already incorporated in the yarn.   
the project 3d-lighttrans succeeded to develop most of the technologies and components required for the cost efficient manufacturing of 3d textile reinforced composites, based on hybrid yarn with thermoplastic matrix. a comprehensive modelling and simulation toolbox was developed. equipment and processes were adapted for the manufacturing of hybrid yarn, the weaving of high performance 3d-shaped and multilayer fabrics and the pre-fixation of the fabrics. significant progress was also achieved with regard to the draping process and tools, as well as in the thermoforming process. a tailgate for fiat 500l and a spare wheel well for bentley demonstrates the applicable results. the project work was awarded with the innovation price for reinforcement by jec paris 2015.  
  
project context and objectives:  
the goal of 3d-lighttrans project was to provide ground-breaking, highly flexible and adaptable low-cost technologies for manufacturing of 3d textile reinforced plastic composites, including innovative approaches for the individual processes and its integration in complete manufacturing chains, which enables to shift them from its current position in cost intensive, small series niche markets, to broadly extended mass product applications, not only in transportation, but also in other key sectors, like health and leisure.  
  
the main process steps are:  
1. hybrid yarn manufacturing. hybrid yarn, composed of reinforcement material and thermoplastic matrix, is produced using a flexible and reliable manufacturing process. the hybrid yarn can be realised with customised properties and different compositions.   
2. weaving. the hybrid yarn is woven to create multifunctional textile preforms, such as double shell or spacer fabrics, and multilayer fabrics, with fibre architecture suited to the desired deep draped form of the final part.   
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results  
modelling and simulation toolbox. a comprehensive simulation toolbox with four major modules has been implemented by ugent, crf, onera, uorl and tu-dresden. the four modules cover the following aspects: a) meso-scale modelling of the dry fabric architecture, b) draping of the dry fabric architecture and fixation of certain areas of the dry fabric, c) thermoforming of the fabric, and d) micro-, meso- and macro-scale modelling of the final composite part. finally, the modelling of the complete process chain is addressed by gze using the software arena.   
the modelling and simulation tools developed were tested through experimental data with yarns, test fabrics and thermoformed plates, with key contribution of leitat and svum. the analysis performed include, among others, single fibre and yarn tensile tests and yarn friction tests; uniaxial, biaxial and shear testing of fabrics; friction, compaction, bending and forming tests on fabrics, ultrasonic inspection of the impact of moisture absorption on the thermoformed plates, impact test and micro-ct scans.   
manufacturing of hybrid yarn and 3d textiles. hybrid yarn combines glass reinforcement with thermoplastic matrix filaments in a single yarn. among the different available technologies commingled hybrid yarns produced by air texturing display a particularly high potential for continuous-fibre-reinforced thermoplastics, due to their great impregnation quality. in air texturing, the hybrid yarn is produced by the pneumatic opening of the filament yarn by cold or hot pressurized air, and the subsequent reallocation of the initial filaments in a special air nozzle. pd-goschatz, tu-dresdentud and ugent have optimized the process to produce highest yarn quality with increased reproducibility and productivity (approx. 50 m/min) in a variety of materials (including pp and pet) with different fibre-matrix ratios.   
concerning the weaving of 3d textiles, on one hand, tu-dresden has produced fabrics with different multilayer patterns, both with z-reinforcement (in different orientations) and without. the four electronic warp let-offs systems and 20 head frames at the new dornier loom (modified for the 3d-lighttrans technology) make it possible to produce the multilayer fabric based on gf/pet 840 tex (final yarn architecture) with high warp density, an optimized shedding operation and more structural variety, keeping highest fabric quality and reducing fibre damages. on the other hand, vandewiele has developed industrial equipment available at tu-dresden to manufacture 3d shaped reinforcement textile pre-forms with customized multifunctional structure. in contrast to the conventional spacer fabrics (pile weaves) connected by additional pile yarns, the 3d woven spacer fabrics are constructed of woven outer layers connected by crosslink fabrics. such structures do not only possess superior mechanical properties, but can also be produced -using vandewiele, equipment- in just one process step.  
manufacturing of the consolidated final composite part. the state-of-the-art technology provides neither standard tools, nor automated procedures with sufficient flexibility to perform in a satisfactory way the draping of complex geometries with thick multilayer fabrics. 3d-lighttrans approach to solve this consists in decomposing the procedure in several steps: pre-fixation, automated draping in a dummy tool, fixation, and final consolidation by thermoforming.  
in order to decrease the fabric handling and draping effort, the fabric is pre-fixated, which creates a local increase of mechanical stiffness in well-defined areas previous to the draping. in a novel approach, special fibres with modified characteristics are integrated in the fabric by tu-dresden, and subsequently processed by coatema using alternative heating methods.   
as a result of the pre-fixation, draping becomes easier, the flow of forces is better balanced and the number of wrinkles is reduced. in spite of this, the automated draping still constitutes a challenge, addressed by promaut and leitat. to handle the fabric, experimental tests have been done with suction cups and needle claws, while performed analytical studies show the influence of relevant parameters, such as the air leakage in vacuum grippers as a consequence of the fabric porosity and roughness. the implemented force control system makes path programming easier and ensures a constant draping force of the fabric against the tool. while the simulation performed by tu-dresden provides a first estimation of the effectiveness of a given draping strategy, robot studio simulation allows a quick verification of the robot path reachability and draping tool placement.  
one of the key advantages of the 3d-lighttrans technology is the processing to 3d fixed pre-forms, previous to the final consolidation (fixation). the pre-forms with fixed 3d geometry can be easily stored and transported without altering their geometry.   
to achieve good results of the final composite part, the thermoforming process has to be adapted to the needs of the 3d-lighttrans technology. flat multilayer textile reinforced composite plates have been consolidated by thermoforming at fmsp varying the pressure applied, time and temperature, for a number 3d-lighttrans fabrics of different characteristics. the resulting thermoformed plates have been visually inspected and analysed by ct-scans, micrographs, and measurements of thickness, impact behaviour and other mechanical properties. in parallel to the investigations on flat plates, a small complex tool is used by lkr, combining long plane areas on the bottom and side walls, with both long and tight curvature areas, to investigate the process stability to manufacture parts with close concave-convex geometry curvatures.  
the 3d-lighttrans manufacturing chain. the 3d-lighttrans project integrates the novel process steps described above with a knowledge-based manufacturing approach and full automation, in order to provide a totally new concept for the design, manufacture and application of high-tech composites for low cost mass products. while the modified air-texturing machine can produce hybrid yarn with high repeatability in a variety of materials (such as glass/pet and glass pp) in different fibre/matrix ratios, the weaving equipment enables an increased flexibility in the realization of high-performance 3d fabrics. storage and transport of the fixed pre-forms (if required) can take place without refrigeration requirements, as customary with thermoset prepegs.   
the manufacturing chain is very flexible and can also be adapted to different production configurations. gze has defined and tested a framework for the production line design, using modelling and simulation methodologies, which has been tested in a specific test case. test, reliability and quality assurance aspects over the whole manufacturing chain are addressed by leitat und svum. in order to ensure the real deployment of the 3d-lighttrans technology, in a holistic approach, relevant aspects such as an impact study (realized by xedera), business cases (ait), product life cycle (crf, ait, gze), and scale-up for mass production are also considered.   
  
all in all the consortium brought together multidisciplinary research teams involving industrial stakeholders from machine tools and machine automation (p-d glasseiden oschatz, michel van de wiele, lindauer dornier, coatema) and several oem active in the field of processing of flexible materials and composite manufacturing, including federal mogul systems protection, among others, as well as from the application sector (centro ricerche fiat and bentley), and extensive expertise from well-known research specialists in the area of materials, production research and technical textiles in particular, such as ait austrian institute of technology, tu-dresden and university of ghent. the modelling and simulation played an important role and achieved interesting results for science as well as for the application. these results were accomplished by university of ghent, tu-dresden, university of orleans, office national dâetudes et de recherches aerospatiales (onera), grado zero espace (in italy). the development of the concept and model for the whole manufacturing chain automatitzacio de processos i mediambient (promaut, spain) was responsible. tests on the yarn, the woven fabrics, the thermos-pressed parts, and the tests on the final component are done by leitat (acondicionamiento tarrasense associacion, terrassa spain) and svum (czech republic). xedera (austria) manages the website, the exploitation and dissemination.  
  
a short film about the project work and the main results are available under https://www.3d-lighttrans.com/wp-content/uploads/2015/05/3d\_lighttrans\_videofinal.mswmm1\_.wmv  
for further information please see: www.3d-lighttrans.com.   
  
project results:  
description of the main results  
modelling and simulation   
the modelling and simulation tools developed in the 3d-lighttrans project are validated and tested through experimental data the scope of modelling and simulation was to provide advices for the design of the fibre reinforcement and the manufacturing process. therefore, sensitivity analyses on the developed models were done. the parameters that influence the several process steps and, thus, important indications could be determined.   
the 3d-lighttrans composites, as textile composites in general, have three characteristic scales:  
1) micro-scale: at the micro-scale, the constituents (fiber and matrix) are treated separately. the micro-scale representative unit cell (ruc) has to contain sufficient fibers, such as to well represent the statistics of the fiber distribution within the yarns. if only the elastic properties and the ultimate tensile strength in fiber direction are considered, a hexagonal ruc containing only one fiber is sufficient. the aim of micro-scale mechanical modeling is to compute the mechanical behavior of the consolidated yarns from the constituent behavior, taking into account the fiber volume fraction and its waviness.  
2) meso-scale: at the meso-scale, the architecture of the reinforcing fabric is represented. the consolidated yarns are modeled as a homogeneous transverse isotropic material with properties obtained from micro-scale modeling or from experiments on consolidated yarns or ud-plates. the aim of meso-scale mechanical modeling is to compute the average mechanical behavior of the consolidated composite, taking into account the fabric architecture and the yarn shapes.  
3) macro-scale: at the macro-scale, the structural aspects of the composite part are modeled. the composite material itself is modeled as a homogeneous anisotropic material with properties obtained from calculations at the lower scales or from experiments.  
  
modelling of impact and crash behaviour  
based on experimental results, different numerical modelling strategies are investigated in order to obtain the best correlation between numerical and experimental results under impact load by means of a sensitivity analysis of the different parameters influencing the results of the finite elements simulations at macro scale. one will use a low impact speed test-setup, experimentally and numerically, since this will represent as closest the impacts a spare wheel well for example will undergo in real circumstances. the procedure is described in details in d2.7 âset of guidelines for optimization of the fiber reinforcement and the manufacturing processâ. the   
the outcome can be summarized in:  
o if one compares the experimental results and the simulated results of this sensitivity analysis, a good correlation can be found by using a combination of a correct finite element model and material model  
o choosing a correct finite element model with boundary conditions as close as possible to reality is important when modeling impact in composites with damage initiation and evolution.   
o this sensitivity analysis gives a first idea of an indication of the different roles of some of the parameters.   
  
meso-scale modelling of the dry fabric  
the goal of the dry fabric meso-scale modelling is to enable qualitative and quantitative comparison of the fabric deformability especially in biaxial extension and compaction. the procedure used for the modelling is as follows:  
1. design of a consistent and representative cad model of the unit cell,  
2. meshing of the unit cell,  
3. finite element simulations of the deformability of the unit cell.  
the input needed for the simulations are: yarn tensile behaviour, yarn compaction behaviour and yarn/yarn friction. results of fabric testing (uniaxial, biaxial, compaction and shear) are used for the validation of the model.  
to characterize the internal structure of the fabrics accurately, micro-ct scans were performed. the analyses of the micro-ct scans have shown that the real internal structure of the fabrics is disordered due to the weaving process.  
  
modelling of the drapability process   
numerical simulation is an important tool for the optimization of the load-bearing behaviour of composites that are reinforced with high performance textile structures. fabrics undergo a high degree of deformation while forming from their initial two-dimensional shape into a complex three-dimensional structure. composites can only carry load in the fibre direction. a small difference between the load and fibre orientations decreases this capacity significantly. because of the high deformations and the anisotropic character of most fabrics the reinforcement orientation in the formed structural part is hardly predictable. therefore, drapability simulations, based on the finite element method (fem), are implemented to predict the fibre orientation and the highly sheared zones and, additionally, to proof the formability of the textile structure itself. classic composite constructions are time- and cost-intensive processes, where iterative development steps for improving the lightweight character have to be made with a high amount of engineering work. uncertainty about the reinforcement orientation hinders an exact stress analysis. the drape simulation offers new possibilities for the designing of composites. the formability of the textile reinforcement structure to the intended three-dimensional geometry can be proofed. furthermore, it becomes possible to predict the fibre orientation and, thus, weak spots in the component. the drape simulation is also a basis for resin injection and structure simulations.   
in this section the developed model is used to define the most influencing fabric and process parameters. therefore, representative material properties (tensile-, shear- and bending behaviour) of the 3dlt/8/vdw-ncfd-400:6-240:5/6 fabrics are varied and the influence on results of the tensile and the picture frame test are analysed. for the investigations of the drape process the tetrahedron punch test of uorl was chosen. in this test the pressure exerted by the blank holders and the friction coefficients were varied.   
  
modelling of the thermoforming process   
a series of thermoforming simulation cases were set up on a u-section geometry, provided, in order to do a sensitivity analysis. the decision of performing a sensitivity analysis was taken, since no material data from experimental test were available, neither from the other partners, nor from esi.  
in order to perform the sensitivity analysis, some parameters change among different simulation cases.  
  
multi-objective-analysis  
the multi objective analysis developed within 3d-lighttrans promotes the integration of the various levels of computational analysis on the materials, the processes and the demonstratorâs performances in order to determine the best design and process input parameters. the objective of the work done is to obtain a set of feasible solutions placed on the pareto optimum frontier considering the objectives (minimize cost, maximize the mechanical strength, etc.) and the bonds (maximum angle limit between warp and weft direction after draping operations, satisfactory displacements on the component, resistance to impact when hit by bodies, etc.).this set of solutions will be then the starting point for the choice of the optimum parameters for the demonstrators design and manufacturing.the optimization process consists of a set of steps organized in a linear workflow. every step of this workflow must be automatic (no user intervention required) and in the same time robust to the possible errors coming from simulations. this process will be then looped in the optimization phase considering the results of the global doe plan.  
the optimizer adopted in the multiobjective analysis is a moga-ii optimizer. moga-ii is an improved version of moga (multi-objective genetic algorithm); it uses a smart multi-search elitism for robustness and directional crossover for fast convergence. its efficiency is ruled by its operators (classical crossover, directional crossover, mutation and selection) and by the use of elitism (ref. ânbi and moga-ii, two complementary algorithms for multi-objective optimizationsâ, 2006).  
on the basis of the first optimization runs it will be evaluated the relevance of both the analysis steps and the input variables in order to exclude the less influential on the final objectives of the optimization from the list of input proposed by the involved partners (e.g. in the step of the mechanical tests on the part geometry, if the component will always satisfy the required constraint on one of the load cases).  
  
modelling and simulation of the complete process chain  
manufacturing modelling and simulation is the process of creating and analysing prototypes (usually digitally realized), of real-world facilities or processes (either actual or planned), to predict their performance. the facility or process exists and operates in time, and it is referred with the generic term of system. manufacturing simulation modelling (a general term that spans across many fields, industries, and applications), deals with the collection of methods and techniques in using computer tools (usually software), to mimic the behaviour of real-world systems, evaluating them numerically, and estimating their desired characteristics.  
our primary goal in simulation was to focus the attention on defining and understanding how the system work, or should work (this is the case in which system does not exist), task that provided a great insight view about the changes that need to be made during the development of the manufacturing activities.  
the creation of simplified representations for the system under study (models), was guided by a prescribed set of goals, specific objectives of the study that should make possible (many of the processes are still going and are still under developing, especially pre-fixation and fixation, draping and thermoforming), to proceed in experimenting with the system (with the manufacturing line), through its models (when they will be fully implemented and industrially deployed).  
experimentation consists in generating system's histories and observing system's behaviour over time, as well as statistics about how it works; this particular task that is usually called data collection, is the principal source of information for the verification and validation stage of every type of simulation conducted over systems, and so partially was in this case, and will be, in a more effective way, when all the manufacturing processes will be totally developed.  
models, in manufacturing simulation studies (those presented below), are discrete (even if they are capable to incorporate some continuous variables - rates of change), dynamic (non-static), and stochastic (non-deterministic), and are henceforth called discrete-event simulation (des) models.  
  
manufacturing process for 3d textile fabrics  
the objective was to develop industrial models, technology and adaptation of processes for the implementation of the individual manufacturing processes, in order to enable 3d-lighttrans approach for sustainable and efficient production and manufacturing based on flexible materials, integrating hybrid yarn manufacturing and weaving processes. the research focus was on the production processes and the related manufacturing systems for the processing of such flexible materials.  
manufacturing of hybrid yarn according to process stability and demonstrator requirements  
the first important step was the development of the technology to enable air mingled hybrid yarn manufacturing to meet the 3d-lighttrans requirements, which constitute the novelty in this area. this is a technology for highly flexible manufacturing of hybrid yarn incorporating alternative thermoplastic materials, with configurable material and mixture distribution, homogeneous distribution and minimum fibre damage. as a result of the technology development, hybrid yarn with glass fibre were developed and produced by pd-goschatz with different fibre volume content and yarn count, and with the best possible mixing which still guarantees a homogeneous distribution and the shortest possible cycle time. in addition, special effort was devoted to further development of the technology in order to ensure  
a) very high reproducibility of the composition of the hybrid yarn, meeting the requirements the demonstrators of the car industry (tailgate for cr fiat and spare wheel well for bentley).  
b) increased productivity also with other 3d-lighttrans matrix materials (pet), additional to the conventional matrix material for hybrid yarn (pp) and to alternative reinforcement yarns.  
c) reduction of fibre damage during the air texturing process, in order to maintain in the composite the properties of the raw reinforcement fibre material as close as possible.  
final specification of the hybrid yarn: mixture ratio of 70:30 % mass content (gf/pet) with yarn count of 840 tex.  
manufacturing of the semi-finished pre-fixed forms  
after trials and tests for the selection for the multilayer fabric the following architectures was chosen. the fabric with vertical z-reinforcement displays shows better impact properties, based on the finals yarn architecture. further characteristics of the final fabric structure are as follows:  
âª number of warp layers: 4   
âª number of weft layers: 5   
âª weft and warp yarn: gf/pet 840 tex   
âª z-yarn: gf/pet 840 tex   
âª weft density: 240 yarns /10cm   
âª warp density: 240 yarns /10cm   
âª z-reinforcement density: 24 yarns /10 cm (gf/pet)   
  
the new lindauer dornier loom  
the new lindauer dornier loom compared to the standard weaving machine from dornier is adapted and enhanced to produce the multilayer fabric based on gf/pet hybrid yarn.   
the new dornier weaving machine was installed successfully at tud and a fabric of gf/pet 840 tex was produced with it.   
modification of the new dornier loom  
to produce the fabric at the highest quality, and to reduce the yarn damages which typically occur on multi-layered weaves, several modifications (described in the following) have been made of the new weaving machine to minimize yarn damage during weaving and to achieve maximum mechanical properties.  
novel warp beam concept, with specially designed tension bars  
the new machine has a novel warp beam concept, with specially designed tension bars (figure 8). each beam has separate warp tension sensors (figure 9, figure 10).this new concept makes it possible to control the warp tension regularly and avoid yarn damage during the weaving process. tension control is possible from the ft-panel which is totally new in comparison to the old dornier loom.  
the multilayer fabric produced on the new loom has a thickness of 5 mm (gf (55%)/pet (45%) volume content), and the composite based on the fabric has a thickness of 2.5 mm.  
the 3d-shaped / spacer fabric  
3d woven spacer fabrics are constructed of woven outer layers connected by crosslink fabrics. this allows thermoplastic based 3d preforms using gf/pet hybrid yarns to be manufactured in just one process step possessing good mechanical properties such as compressive, tensile, flexural strength, impact, and resistance.  
spacer / 3d-shaped fabric structure  
âª weft and warp yarn: gf/pet 840 tex  
âª z-yarns: gf/pet  
âª for each plate: 5 weft and 4 warp layers  
âª density of the yarns:   
â¢ 300 weft/10cm/plate   
â¢ 120 warp/10cm/plate  
â¢ thickness of the plate: approx. 2 mm  
the new michel van de wiele loom  
the design of specific fabric take up motion, for taking 3d shaped fabrics had to take into account the adaptations on the base platform for allowing the assembly of lay back system with the design of the beam stand and the double drive system, the software development for actuation of the backwards motion, and developing the new configuration to control the tension of the warp beam.  
  
manufacturing processes of 3d-lighttrans final compound  
the process required the development of the individual industrial models, technology and adaptation of processes for the implementation of final part draping and thermoforming manufacturing processes, in order to enable 3d-lighttrans approach for sustainable and efficient production and manufacturing based on flexible materials, integrating specifically draping and thermoforming of the final part. based on the steps described above the research has focused on the production processes and the related manufacturing systems for the processing of such flexible materials.  
  
draping  
the draping process was developed for the challenging deep drawn component of the spare wheel well. to conclude the achievement of the draping process can be summarized: the project achieved an automated, robotized solution for the complex process of draping with a mechanical, electrical, and programming demonstrator.  
  
prefixation  
the following results have been achieved during the 3d-lighttrans project.  
â¢ pre-fixation is possible with ir-radiation, but the operating window is small.   
â¢ pre-fixation is as well possible with xenon flashes, the operating window being similar small as with ir. but the effect of xenon flashes is controllable by the colour of the fibres.  
â¢ by integrating some black pet yarns into a fabric the pre-fixation process can be restricted to well defined areas.  
â¢ the bending stiffness of such fabrics, being pre-fixated in stripes only, is significantly higher than without pre-fixation.  
â¢ although the melting behaviour of pet is significantly different from pp, the result looks very similar to the trials with pp-fibres, so the combination glass/pet should be fixed in the same way as glass/pp.  
â¢ alternatively a black pet powder could be used instead of black pet-yarns for a local pre-fixation of glass fabric. milled pet powder with 0 â 80âµ particles then should be used to achieve a homogeneous bonding. such pet powder is commercially available.  
  
fixation  
1. fixation of draped fabrics using black pet powder as adhesive is possible by melting the powder with flash light irradiation. but the focus ability of the flash light to the areas of interest is difficult.  
2. alternatively the pet powder can be molten by lasers of appropriate wavelength and power. such lasers are sufficiently small to be guided by a robot and thus will be focussed to irradiate the areas of interest only.  
  
proposals of technical realization  
pre-fixation: weave black pet yarns into the fabric at the areas to be pre-fixated and melt them by flash light immediately ...

# 2BFUNTEX

Project Acronym: 2BFUNTEX

programme & topic: FP7-NMP NMP.2011.2.3-3

Most frequent returning words in objectives:

* ('research', 53)
* ('industry', 39)
* ('project', 39)
* ('information', 36)
* ('materials', 34)
* ('textile', 32)
* ('innovation', 27)
* ('textiles', 26)
* ('technologies', 24)
* ('projects', 19)
* ('teams', 18)
* ('multidisciplinary', 17)
* ('objective', 16)
* ('partners', 16)
* ('foresight', 16)
* ('needs', 15)
* ('researchers', 14)
* ('activities', 14)
* ('gaps', 13)
* ('structures', 11)
* ('universities', 11)
* ('institutes', 11)
* ('order', 11)
* ('stakeholders', 11)

executive summary:  
2bfuntex is a coordination and support action (csa) launched in 2012 within the european fp7 nmp programme. the objective was to bring together innovation actors in the field of functional textile structures and textile related materials, fostering a multidisciplinary approach between universities, research institutes, industry (especially smes) and sector associations. the 2bfuntex team (26 partners from 16 countries) aimed to identify technological gaps and eliminate barriers resulting in a faster industrial uptake of functional materials with new functionalities and improved performance. technological needs were mapped, new joint international research disciplines identified and multidisciplinary teams created. as an industry-oriented approach was envisaged, industry has been involved at all stages which should also contribute to a rapid uptake of innovations by smes.   
  
one of the main objectives of 2bfuntex was to develop a platform for current and future actions in research, education and technology transfer in the field of functional textile structures and textile related materials to support the textile industry in the most efficient and effective way to transform into a dynamic, innovative, knowledge-driven competitive and sustainable sector. the established open innovation platform www.2bfuntex.eu is the place for both companies to detect new technologies and business opportunities as well as to express their needs, and for research institutions to present their current and future actions in research and education, and their available technologies. based on the information gathered in the project inventory, researchers and industrials have been invited to participate in research projects aiming to exploit the untapped potential and leading to the development of new industrial products.  
  
another main objective was to support research and industrial innovation actors, i.e. universities, research institutes along with industry, in their efforts to define joint research projects and actions in the field of functional textile structures and textile related materials. the aim was to set up multidisciplinary teams in order to enhance transfer of the vast knowledge available at universities and research institutes to industry and to favour rapid industrial uptake. based on the analysis of the technology-innovation gaps, 8 multidisciplinary teams (mdts) that collaborate along the following specific research topics were identified and set up : antimicrobial textiles, smart textiles, nanotechnologies, flame retardancy, biotechnologies, electrospinning, plasma and sustainable textiles. each mdt is led by a research and an industrial team leader and will identify tangible gaps between available technologies and medium to long-term industrial needs. all mdts are also open to researchers and industrial persons from outside the 2bfuntex consortium.  
  
during the project, six complexity and foresight workshops were organized to look at scenarios for the future of functional textiles, using also the systems thinking methodology. the foresight process finally resulted in concrete action planning for the multidisciplinary teams.  
  
training materials for research and industry purposes have been elaborated and implemented, allowing a common language regarding functional textiles, and increasing the number of well-trained people in this field. these training modules can be used in all european universities and research institutes to train their students at different faculties and by sector organisations to train technical people in their smes.   
  
in order to promote the 2bfuntex coordination action and the open innovative platform, 9 large 2bfuntex events have been organised (conferences, workshops, brokerage events, ...), and seven 2bfuntex newsletters were published and widely disseminated across europe towards main textile stakeholders, as well as published on the 2bfuntex website.  
  
  
  
project context and objectives:  
the 2bfuntex project dealt with closing the gap between research and industry in the field of functional textile structures and textile related materials, also sometimes referred to as advanced or high tech textile materials, such as breathable, heat and cold resistant materials, ultra strong fabrics; providing protection against chemicals, impacts, laceration or used as reinforcement for composite applications, new generation of flame retardant fabrics (intumescent materials, new developments of fibres), optimisation of textile fabrics for acoustic properties,....  
  
2bfuntex brought together researchers in different complementary research areas to allow enhanced development of functional textile structures and textile related materials through collaboration at european level between researchers in different universities, research institutes and industry. involving industry at all stages of the coordination action enhanced the industry oriented approach of the project. the involvement of industry, especially smes, in defining research activities aims at enhancing the rapid uptake of innovation by smes resulting in overcoming the "european paradoxâ. moreover, 2bfuntex aimed at increasing the number of well-educated people in textiles and textile related industries to allow for close collaboration with research institutes and to stimulate enhanced uptake of innovation by smes. the coordination activities have fostered an environment in textiles and textile related industries that attracts highly skilled people.  
  
the concept of this collaboration network was to encourage interdisciplinary research work to enable the development of functional textile-based structures of tomorrow. the combination of novel materials such as ceramics, metal powder and foam, glass powder and other down-scaled materials into new structural textile-based elements is only possible by the close collaboration between innovation actors from different science areas. surface modification of textile based materials using modern technologies such as physical vapour deposition, sol-gel coatings, laser cladding, plasma treatment, etc. provide new opportunities only when close collaboration is established between researchers of different disciplines. the combination of flexible, light-weight textile-based material originating from renewable resources used in biomimetic structures together with eco-friendly biotechnology have a successful and convincing potential which can be used and exploited only to its full extent when bringing together the most excellent researchers in europe and start creating multidisciplinary project teams.  
  
2bfuntex brought together a large group of researchers from universities, research institutes and enterprises along with several stakeholders such as sector and industrial organisations. through their joint experience, it was observed that much effort is invested in the development of new textile-based materials, thus developing new functional materials. however, it was also observed that much research is being duplicated and not enough researchers from different disciplines are collaborating. new opportunities are left untouched or even remain undiscovered because researchers are unaware of one anotherâs needs. moreover, because researchers are not actively collaborating, they cannot create synergies and they cannot learn from one another, which hinders the generation of new ideas. as the end-users are not aware of the enormous potential, they are not asking industry to develop new textile structures.  
  
conclusion, a significant amount of money is being invested in europe to develop functional materials. however there is a real need to put the results of all activities and policy building together in order to exploit the results, to avoid duplication, to benefit from experience gained and to align future research activities.   
  
scientific &technological objectives  
  
2bfuntex aims to be the market place for all stakeholders involved in functional textile structures and textile related materials to allow the traditional textile sector to move away from traditional products to speciality products manufactured by advanced flexible high technology, knowledge based new fabrics and specific applications. the objective was to develop a platform for current and future actions in research, education and technology transfer in the field of functional textiles in order to improve the competitiveness of the textile and associated european industries and to support the textile industry in the most efficient and effective way to transform into a dynamic, innovative, knowledge-driven competitive and sustainable sector.   
  
2bfuntex main objective was to support research and industrial innovation actors, i.e. universities, research institutes along with industry, in their efforts to define joint research projects and actions in the above mentioned field. the aim was to set up multidisciplinary project teams oriented towards untapping the experienced potential related to functional materials and to enhance transfer of the vast knowledge available at universities and research institutes to industry and to favour rapid industrial uptake.  
  
the overall objectives of 2bfuntex comprise :  
  
objective 1: collecting all relevant information related to ongoing research and activities in the field of functional textile structures and textile related materials using modern detection methodologies.  
  
collecting information was the first objective of the 2bfuntex project. though a reasonable number of projects related to functional materials was being performed, industrial uptake and collaboration between innovation actors were limited. the project partners were involved in some of the projects but many more projects were on-going although not known to the larger research and industrial world. moreover, information regarding the projects was not always available to the broader public of industry and end-users. this lack of information resulted in double work, ignorance regarding the potential of functional materials and untapped potential regarding collaboration between different disciplines that need to join together to develop new functional materials.  
  
as the 2bfuntex team acknowledged this lack in information but also recognized the difficulties in collecting the information, fulfilling the objective was done by using modern supporting detection methodologies. as such, prior to launching the inventory, innovation management was dealt with from a complexity perspective and so bringing all stakeholders together, i.e. on the one hand the traditionally perceived innovation actors such as researchers, developers, manufacturers (technical and managerial people), distributors, end users (those who decide on purchase and those who actually use the products) and on the other hand stakeholders that influence the decision making process throughout the whole process such as investors, regulators, social actors, etc. the outcome was supposed to reveal bottlenecks and identify opportunities and was used as basis to initiate the collection phase.  
  
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â¢ ongoing/finished projects on national and international level;  
â¢ partners involved/contacts;  
â¢ technologies to be developed;  
â¢ technologies developed (general description);  
â¢ applications envisaged;  
â¢ status of the project;  
â¢ available material (descriptions, movies, demonstrators, roadmaps, presentations, newsletters, etc.);  
â¢ conditions of access of materials;  
â¢ standardisation issues.  
  
the information encompasses project title, timing, links to additional information (e.g. project website, contact details, etc.). it is presented in a way that is relevant to the different target groups (easy to read, right level of detail, ...).  
  
the inventory also includes the collection of information regarding planned activities, including data and place, topics covered, nature, targeted audience, conditions of participation, etc. all partners are expected to transfer information on upcoming events. considering the overall size of the networks in which the project partners are active, the information gathered is quite comprehensive.   
  
the search has been performed using accessible information on the internet, but mainly by contacting universities, research institutes and industry personally through questionnaires as well as face-to-face meetings.  
  
all the information collected has been classified in a structured way. part of the information is non confidential, so that it is accessible to all interested parties. confidential information is classified in a separate file with restricted accessibility: project partners, eu officers, members of the 2bfuntex platform, multidisciplinary team members, ....  
  
objective 2: detection of synergies and gaps and the creation of project ideas  
  
the 2bfuntex team responded to the observed lack in synergy between researchers on the one hand and between industry and researchers on the other hand. the results obtained in the inventory phase have been used to detect current synergies that need to be reinforced, potential synergies that are currently neglected resulting in duplication of work or even resulting major untapped potential and gaps that exist because of complementary partners and disciplines not collaborating together (e.g. materials sciences and environmental engineers). detection of synergies and gaps has been performed by the individual teams that collect the data and assisted by one of the partners well experienced in identifying these synergies and gaps. the information has been used to create project ideas to be elaborated in tangible project teams and concrete rtd projects to enable the effective technology transfer to industry.  
  
objective 3: development of an interactive database  
  
information sharing is one of the key activities to involve more stakeholders, to enhance data collection and to increase general public awareness. 2bfuntex has therefore developed a database with full information on activities on functional materials. this is a tool box that interested parties can use to find components that might fit for a certain application of functional materials, status of technology, people involved, contacts, possibilities and limitations. in addition, ongoing projects can use the database as a portal for disseminating information and contacting targeted people.  
  
the outcome is a database with all functionalities that are currently under consideration, parties working on it, status and contacts. it contains technological as well as non-technological information. efforts have been made to link the database to existing initiatives such as the european technology platform for textiles and clothing, etc. further, links are available to other existing networks.   
  
objective 4: provision of training and education to increase the number of well-trained people that continue their (research) activities in industry and to better train people already employed in industry  
  
training is considered as transfer of information related to functional materials, its components as well as integration and use aspects. several universities being involved, education and training is the core competence for many 2bfuntex partners. moreover, one association combining research activities and training activities dedicated to smes participated in the project. knowledge has been shared to allow for a well-balanced training course that can be used both for education and training purposes.  
  
objective 5: dissemination activities  
  
dissemination is considered as transfer of information regarding the 2bfuntex project, its activities and results. the results of the project have been disseminated within and outside the consortium. confidential information has been communicated based on agreed non-disclosure or other agreements to ensure the maximum exchange of such information and materials. non confidential research reports have been spread among academia and other research centres and networks in order to make them aware of existing technologies or technologies under study. comprehensive and at the same time concise reports have been issued for industry. future researchers and technical people have been informed on the available technologies through training and education. companies have been informed on potential functionalities so that they can consider applications within their product and market ranges. product information has been spread to potential user groups as well as to a wider public in order to raise awareness of the potential and to increase acceptance of such technologies on a longer term.   
  
special attention has been paid to bridging the gap between textiles, materials sciences, textile engineering, environmental engineering, green technology/biotechnology, civil engineering, surface engineering, composites, plastics, bio-engineering, chemistry, physics engineering, etc. ... and users (in the protective clothing as one of the ppe lead market segments, transport, automotive, aeronautics, electronics, construction, etc.).  
  
objective 6: creation of multidisciplinary teams performing research in the field of functional materials and oriented towards industry aiming at the creation of new business worldwide  
  
the final goal and objective of 2bfuntex was to consolidate all information gained in solid collaborations between research and industry resulting in the enhanced identification of new functional materials and rapid translation of research ideas in industrial applications. the research ideas will lead to industrial applications of added value functional materials with new functionalities and improved performance and resulting in creation of new business worldwide. ideas have been initiated based upon the inventory (objective 1), and subsequently 2bfuntex has assisted in the consolidating process of matching synergies and closing gaps by the creation of multidisciplinary project teams collaborating in concrete research projects targeting the effective transfer of novel technologies in the functional textiles industrial sector. moreover, 2bfuntex assisted the discussing process on legal and practical aspects.   
  
  
project results:  
,the 2bfuntex project was structured in 5 work packages. in the following section the s&t results produced during the projects lifetime are presented per work package.  
  
wp1 : inventorisation of related projects, technologies and industrial needs & creation of project ideas  
  
the overall objective of this wp was to collect technological as well as non-technological information on functional textile structures and textile related materials. to collect all relevant data, the inventory has been performed at various levels:  
â¢ research performed in research institutes, universities, r&d centres in (mostly large) companies, etc.;  
â¢ needs detected in companies, from end users and stakeholders;  
â¢ compiling existing standards;  
â¢ detection of synergies and gaps;  
â¢ workshops, (brokerage) events and conferences organised and to be organised;  
â¢ funding opportunities already provided and available for research and demonstration projects in this field.  
  
task 1.1: innovation management and systems thinking (complexity and foresight)  
  
the 2bfuntex innovation model   
within complex innovation systems, innovation can be seen as the change that outperforms the previous practice. in order to lead or sustain with innovations, managers need to concentrate heavily on the innovation network which requires deep understanding of the complexity of innovation. collaboration is an important source of innovation. innovations are increasingly brought to the market by networks of firms, selected according to their comparative advantages, and operating in a coordinated manner. when a technology goes through a major transformation phase and yields a successful innovation, then it becomes a great learning experience not only for the parent industry but for other industries as well. big innovations are generally the outcome of interdisciplinary networking among technological sectors along with a combination of implicit and explicit knowledge. networking is required but network integration (networking of networks) is the key to success for complex innovations in todayâs era where diverse technologies are available at its best.  
  
in order to lay the foundation for analysing the 2bfuntex innovation approach, two methodologies were introduced and used to tackle the complex system of the 2bfuntex environment. systems thinking was used to reveal the underlying characteristics and relationships of systems, while methods of foresight helped to build medium and long-term visions of development of the science, technology and innovation, its policy, directions and priorities as well as supporting network activities.   
  
the task was workshop based: each workshop brought together the appropriate consortium partners and innovation actors. each workshop delivered a new enhanced version of the common understanding of interactions and scenarios, including adjusted guidelines for the information survey.   
  
during the project, six complexity and foresight workshops were organized:  
1) 7 - 8 february 2012, ghent, belgium: the objective was to create a common understanding of the work to be accomplished within the 2bfuntex project among the project partners. a first version of the 2bfuntex innovation model was developed. the results were documented as deliverable 1.1 âreport on first complexity and foresight workshopâ.  
  
2) 11 - 12 june 2012, zadar, croatia: the aim was to build a common knowledge based on the expected benefits and procedures of a stakeholder-based foresight process among participating partners. important topics and key stakeholders were identified to be included in the next workshops and events.  
  
3) 7 â 8 january 2013, eibar, spain: this workshop focused on exploring potential application scenarios with a clear industry perspective. six members of the industrial advisory board (iab) presented their insights and voiced their expectations as âindustry success criteriaâ for 2bfuntex.  
  
4) 28 - 29 may 2013, istanbul, turkey: this workshop aimed at âaction planningâ of three of the eight multidisciplinary teams. a special working session on building framework scenarios was conducted.  
  
5) 1 â 2 april 2014, brussels, belgium: one of the main tasks in this workshop was to focus on near-to-market technologies that already exist and develop one break-through concept based on these near-market technologies. another task was to define one great project idea that industrial partners are likely to pick up and that can be funded in horizon 2020.  
  
6) 27 - 28 january 2015, tampere, finland: the focus of this workshop was on âmultidisciplinary teams (mdts) meet the industryâ. mdts continued to develop joint research project ideas with participating local industry and higher education representatives.  
  
a foresight process was started that finally resulted in concrete action planning for multidisciplinary teams. in the course of the project a common knowledge based on the expected benefits and procedures of a stakeholder-based foresight process among participating partners was built up. relevant stakeholders were identified and invited and further input was gained through members of the industrial advisory board (iab). science-industry knowledge gaps were identified in key application areas (health, transport, energy/building and safety), with respect to promising developments from a user-perspective, and a steep analysis (longer-term socio-cultural, technical, environmental, economic, and political trends) conducted. a common vision of the 2bfuntex project led to a strategy for realizing the vision, technology and market scenarios as roadmap and eventually resulted in action plans for mdts.   
  
a language to better understand complex environments has been developed in mit and is labelled âsystems thinkingâ. this methodology visualizes the interrelations between the many factors that define the behaviour of a complex system. two important patterns in these interrelations are reinforcing loops and balancing loops. reinforcing loops are the âenginesâ that create positive or negative growth. balancing loops are the âbrakesâ that limit the growth. in order to understand how to influence a complex environment, the identification of these loops is critical. they contain tipping points, i.e. zones where small actions may cause large effects.  
  
using the above concepts the tipping points of the 2bfuntex innovation ecosystem were identified and explored. based on this insight, the priorities of the 2bfuntex actions were optimized and additional tasks identified.  
â¢ the combination of the functional textile market, innovation actors and industry is considered to be a complex adaptive system: many agents interact and influence one another and as a result produce a difficult to predict behaviour.  
â¢ through the technique of systems thinking these interactions are modelled as cause-effect relations. this results in what is called a âcausal loop diagramâ.  
â¢ while developing the causal loop diagram, attention is devoted to discovering interaction archetypes like âlimits to growthâ, âshifting the burdenâ, âeroding goalsâ, âescalationâ and âsuccess to the successfulâ.  
â¢ a well-developed causal loop diagram makes it possible â through model interpretation or through model behaviour simulation â to better predict the future behaviour of the complex adaptive system. candidate strategies can be assessed for their impact using them as driving factors within the model.   
â¢ information gathering: deriving guidelines for information survey: what, how, with which resolution and detail.   
  
considering the results of the systems thinking, of the foresight workshops and all efforts within the other work packages of the 2bfuntex project (e.g. training modules, brokerage events) the final causal loop version resulted. the original three loops of prototyping, customer involvement and industrial growth were confirmed. the expected outcomes of the project were defined more precisely. this particularly relates to the foresight process, which is a methodology rather than an outcome. the three major final outcomes of the 2bfuntex project ultimately are:  
â¢ outcome 1: the 2bfuntex website as open innovation platform  
â¢ outcome 2: industrial uptake  
â¢ outcome 3: multidisciplinary teams  
  
2bfuntex vision and strategy  
based on the results of the systems thinking and foresight workshops, the vision and strategy for the 2bfuntex project was developed by the steering group of work package leaders. it was subsequently validated by the project partners and complemented by identifying key stakeholders.   
vision  
1) we need to narrow the gap between different research areas before we can close the gaps between academic research and industry. the textile sector is a conservative/traditional sector compared to e.g. biotechnology, pharmaceutical industry, etc.. there is a gap between new developments in e.g. chemistry and textiles. we should first narrow this gap, amongst others by inviting experts from other fields to collaborate with us in the multidisciplinary teams.  
2) technologies need to be appraised before they can be transferred to industry. the technologies should be available, transferable and upscalable. we need to find a way to transfer the technologies available in research organisations to industry. for this we need a clear vision on which technologies are available that can be upscaled and transferred to industry on a short term, taking into account the value chain aspect.  
3) we need to create awareness, provide state-of-the-art on key technologies. there is a need to educate other sectors how they could use textiles, e.g. provide them with complimentary knowledge by demonstrations of best practices or proof-by-example, etc.  
4) try to match existing technologies with textile industry needs, in order to save time and money. instead of immediately starting new research to solve the textile industry needs, we should first look which technologies available in other sectors could be useful. this should be done within the multidisciplinary teams. if no appropriate technology is available, new research projects should be started to find a solution for the industrial needs.  
5) creation of a community of experts/contact points on functional textiles (for the whole value chain). the 2bfuntex community should be the unique contact place for industry and other stakeholders looking for information on functional textiles.  
  
strategy  
the following measures compose the 2bfuntex strategy to realize the vision:  
1. collect the core competences and cross sectoral activities/partners of each 2bfuntex partner.   
2. identify transferable technologies, e.g. by looking for proof-by-example and through the 2bfuntex open innovation platform.  
3. organise educational activities/workshops (also skills developing/trainings, capacity building).   
4. organise brokerage events. start-up multidisciplinary teams with a focus on specific topics.   
5. a community of experts will be the end result of 2bfuntex.   
  
scenarios to meet industrial needs  
during the workshops the participants also collected information on interesting markets, sectors and technologies such as:  
â¢ sportswear textiles  
â¢ protective textiles and clothing  
â¢ building and construction textiles  
â¢ light-weight composites (transportation)  
â¢ medical/biomedical textiles   
â¢ chemical industry (esp. as supplier)  
â¢ agricultural textiles  
â¢ home textiles  
â¢ geotextiles  
â¢ industrial laundry  
â¢ filters / nonwovens  
â¢ special / innovative fibre manufacturing  
  
partners suggested to prioritize transportation textiles and special fibre manufacturing and pointed out strategic trends such as energy saving techniques, biobased or recycled materials and use of nanoparticles in textiles. finally, âgrand' societal challenges served as âframeworkâ scenarios to investigate how to tackle these in the different sectors.  
in order to increase customer involvement, it is necessary to identify the needs of different customer groups, as customers can be different industrial sectors or direct end-users. a matrix was prepared with different types of customers and their specific needs. this information is included in deliverable d1.8 âfirst reports per envisaged areaâ and is also available for download on the 2bfuntex open innovation platform as a presentation on âtrends and analysis of industrial needs in functional textilesâ given at the 2bfuntex final conference.  
  
roadmapping and action planning  
the next step within the 2bfuntex foresight and complexity approach was to address societal and industrial needs by roadmapping possible solutions and concrete action planning.   
roadmapping  
the 3rd foresight & complexity workshop focussed on exploring potential application scenarios with a clear industry perspective. six members of the industrial advisory board (iab) presented their insights and voiced their expectations as âindustry success criteriaâ for 2bfuntex. they also actively participated in identifying science-industry knowledge gaps in key application areas (health, transport, energy/building and safety) as to promising developments from a user-perspective. this simplified âroadmappingâ exercise allowed to identify research gaps as âpathwaysâ for providing promising novel solutions for industrial needs.  
  
conclusion  
over the course of the 2buntex project, the six 2bfuntex foresight & complexity workshops served as a face-to-face platform to enhance industry-academia coordination and collaboration. they contributed to a better understanding of state-of-the art research approaches and identification of joint research and development (r&d) ideas with participating industry representatives.  
foresight and complexity methods were instrumental for identifying and supporting the eight 2bfuntex multidisciplinary teams (mdts) in developing their competitive r&d profile e.g. by developing medium- and longer-term critical success factors:  
â¢ mdt nanotechnology   
â¢ mdt electrospinning  
â¢ mdt plasma  
â¢ mdt flame retardancy   
â¢ mdt antimicrobial textiles  
â¢ mdt sustainable textiles   
â¢ mdt biotechnologies  
â¢ mdt smart textiles  
detailed information on ...

# 2BFUNTEX

Project Acronym: 2BFUNTEX

programme & topic: FP7-NMP NMP.2011.2.3-3

Most frequent returning words in objectives:

* ('research', 53)
* ('industry', 39)
* ('project', 39)
* ('information', 36)
* ('materials', 34)
* ('textile', 32)
* ('innovation', 27)
* ('textiles', 26)
* ('technologies', 24)
* ('projects', 19)
* ('teams', 18)
* ('multidisciplinary', 17)
* ('objective', 16)
* ('partners', 16)
* ('foresight', 16)
* ('needs', 15)
* ('researchers', 14)
* ('activities', 14)
* ('gaps', 13)
* ('structures', 11)
* ('universities', 11)
* ('institutes', 11)
* ('order', 11)
* ('stakeholders', 11)

executive summary:  
2bfuntex is a coordination and support action (csa) launched in 2012 within the european fp7 nmp programme. the objective was to bring together innovation actors in the field of functional textile structures and textile related materials, fostering a multidisciplinary approach between universities, research institutes, industry (especially smes) and sector associations. the 2bfuntex team (26 partners from 16 countries) aimed to identify technological gaps and eliminate barriers resulting in a faster industrial uptake of functional materials with new functionalities and improved performance. technological needs were mapped, new joint international research disciplines identified and multidisciplinary teams created. as an industry-oriented approach was envisaged, industry has been involved at all stages which should also contribute to a rapid uptake of innovations by smes.   
  
one of the main objectives of 2bfuntex was to develop a platform for current and future actions in research, education and technology transfer in the field of functional textile structures and textile related materials to support the textile industry in the most efficient and effective way to transform into a dynamic, innovative, knowledge-driven competitive and sustainable sector. the established open innovation platform www.2bfuntex.eu is the place for both companies to detect new technologies and business opportunities as well as to express their needs, and for research institutions to present their current and future actions in research and education, and their available technologies. based on the information gathered in the project inventory, researchers and industrials have been invited to participate in research projects aiming to exploit the untapped potential and leading to the development of new industrial products.  
  
another main objective was to support research and industrial innovation actors, i.e. universities, research institutes along with industry, in their efforts to define joint research projects and actions in the field of functional textile structures and textile related materials. the aim was to set up multidisciplinary teams in order to enhance transfer of the vast knowledge available at universities and research institutes to industry and to favour rapid industrial uptake. based on the analysis of the technology-innovation gaps, 8 multidisciplinary teams (mdts) that collaborate along the following specific research topics were identified and set up : antimicrobial textiles, smart textiles, nanotechnologies, flame retardancy, biotechnologies, electrospinning, plasma and sustainable textiles. each mdt is led by a research and an industrial team leader and will identify tangible gaps between available technologies and medium to long-term industrial needs. all mdts are also open to researchers and industrial persons from outside the 2bfuntex consortium.  
  
during the project, six complexity and foresight workshops were organized to look at scenarios for the future of functional textiles, using also the systems thinking methodology. the foresight process finally resulted in concrete action planning for the multidisciplinary teams.  
  
training materials for research and industry purposes have been elaborated and implemented, allowing a common language regarding functional textiles, and increasing the number of well-trained people in this field. these training modules can be used in all european universities and research institutes to train their students at different faculties and by sector organisations to train technical people in their smes.   
  
in order to promote the 2bfuntex coordination action and the open innovative platform, 9 large 2bfuntex events have been organised (conferences, workshops, brokerage events, ...), and seven 2bfuntex newsletters were published and widely disseminated across europe towards main textile stakeholders, as well as published on the 2bfuntex website.  
  
  
  
project context and objectives:  
the 2bfuntex project dealt with closing the gap between research and industry in the field of functional textile structures and textile related materials, also sometimes referred to as advanced or high tech textile materials, such as breathable, heat and cold resistant materials, ultra strong fabrics; providing protection against chemicals, impacts, laceration or used as reinforcement for composite applications, new generation of flame retardant fabrics (intumescent materials, new developments of fibres), optimisation of textile fabrics for acoustic properties,....  
  
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â¢ standardisation issues.  
  
the information encompasses project title, timing, links to additional information (e.g. project website, contact details, etc.). it is presented in a way that is relevant to the different target groups (easy to read, right level of detail, ...).  
  
the inventory also includes the collection of information regarding planned activities, including data and place, topics covered, nature, targeted audience, conditions of participation, etc. all partners are expected to transfer information on upcoming events. considering the overall size of the networks in which the project partners are active, the information gathered is quite comprehensive.   
  
the search has been performed using accessible information on the internet, but mainly by contacting universities, research institutes and industry personally through questionnaires as well as face-to-face meetings.  
  
all the information collected has been classified in a structured way. part of the information is non confidential, so that it is accessible to all interested parties. confidential information is classified in a separate file with restricted accessibility: project partners, eu officers, members of the 2bfuntex platform, multidisciplinary team members, ....  
  
objective 2: detection of synergies and gaps and the creation of project ideas  
  
the 2bfuntex team responded to the observed lack in synergy between researchers on the one hand and between industry and researchers on the other hand. the results obtained in the inventory phase have been used to detect current synergies that need to be reinforced, potential synergies that are currently neglected resulting in duplication of work or even resulting major untapped potential and gaps that exist because of complementary partners and disciplines not collaborating together (e.g. materials sciences and environmental engineers). detection of synergies and gaps has been performed by the individual teams that collect the data and assisted by one of the partners well experienced in identifying these synergies and gaps. the information has been used to create project ideas to be elaborated in tangible project teams and concrete rtd projects to enable the effective technology transfer to industry.  
  
objective 3: development of an interactive database  
  
information sharing is one of the key activities to involve more stakeholders, to enhance data collection and to increase general public awareness. 2bfuntex has therefore developed a database with full information on activities on functional materials. this is a tool box that interested parties can use to find components that might fit for a certain application of functional materials, status of technology, people involved, contacts, possibilities and limitations. in addition, ongoing projects can use the database as a portal for disseminating information and contacting targeted people.  
  
the outcome is a database with all functionalities that are currently under consideration, parties working on it, status and contacts. it contains technological as well as non-technological information. efforts have been made to link the database to existing initiatives such as the european technology platform for textiles and clothing, etc. further, links are available to other existing networks.   
  
objective 4: provision of training and education to increase the number of well-trained people that continue their (research) activities in industry and to better train people already employed in industry  
  
training is considered as transfer of information related to functional materials, its components as well as integration and use aspects. several universities being involved, education and training is the core competence for many 2bfuntex partners. moreover, one association combining research activities and training activities dedicated to smes participated in the project. knowledge has been shared to allow for a well-balanced training course that can be used both for education and training purposes.  
  
objective 5: dissemination activities  
  
dissemination is considered as transfer of information regarding the 2bfuntex project, its activities and results. the results of the project have been disseminated within and outside the consortium. confidential information has been communicated based on agreed non-disclosure or other agreements to ensure the maximum exchange of such information and materials. non confidential research reports have been spread among academia and other research centres and networks in order to make them aware of existing technologies or technologies under study. comprehensive and at the same time concise reports have been issued for industry. future researchers and technical people have been informed on the available technologies through training and education. companies have been informed on potential functionalities so that they can consider applications within their product and market ranges. product information has been spread to potential user groups as well as to a wider public in order to raise awareness of the potential and to increase acceptance of such technologies on a longer term.   
  
special attention has been paid to bridging the gap between textiles, materials sciences, textile engineering, environmental engineering, green technology/biotechnology, civil engineering, surface engineering, composites, plastics, bio-engineering, chemistry, physics engineering, etc. ... and users (in the protective clothing as one of the ppe lead market segments, transport, automotive, aeronautics, electronics, construction, etc.).  
  
objective 6: creation of multidisciplinary teams performing research in the field of functional materials and oriented towards industry aiming at the creation of new business worldwide  
  
the final goal and objective of 2bfuntex was to consolidate all information gained in solid collaborations between research and industry resulting in the enhanced identification of new functional materials and rapid translation of research ideas in industrial applications. the research ideas will lead to industrial applications of added value functional materials with new functionalities and improved performance and resulting in creation of new business worldwide. ideas have been initiated based upon the inventory (objective 1), and subsequently 2bfuntex has assisted in the consolidating process of matching synergies and closing gaps by the creation of multidisciplinary project teams collaborating in concrete research projects targeting the effective transfer of novel technologies in the functional textiles industrial sector. moreover, 2bfuntex assisted the discussing process on legal and practical aspects.   
  
  
project results:  
,the 2bfuntex project was structured in 5 work packages. in the following section the s&t results produced during the projects lifetime are presented per work package.  
  
wp1 : inventorisation of related projects, technologies and industrial needs & creation of project ideas  
  
the overall objective of this wp was to collect technological as well as non-technological information on functional textile structures and textile related materials. to collect all relevant data, the inventory has been performed at various levels:  
â¢ research performed in research institutes, universities, r&d centres in (mostly large) companies, etc.;  
â¢ needs detected in companies, from end users and stakeholders;  
â¢ compiling existing standards;  
â¢ detection of synergies and gaps;  
â¢ workshops, (brokerage) events and conferences organised and to be organised;  
â¢ funding opportunities already provided and available for research and demonstration projects in this field.  
  
task 1.1: innovation management and systems thinking (complexity and foresight)  
  
the 2bfuntex innovation model   
within complex innovation systems, innovation can be seen as the change that outperforms the previous practice. in order to lead or sustain with innovations, managers need to concentrate heavily on the innovation network which requires deep understanding of the complexity of innovation. collaboration is an important source of innovation. innovations are increasingly brought to the market by networks of firms, selected according to their comparative advantages, and operating in a coordinated manner. when a technology goes through a major transformation phase and yields a successful innovation, then it becomes a great learning experience not only for the parent industry but for other industries as well. big innovations are generally the outcome of interdisciplinary networking among technological sectors along with a combination of implicit and explicit knowledge. networking is required but network integration (networking of networks) is the key to success for complex innovations in todayâs era where diverse technologies are available at its best.  
  
in order to lay the foundation for analysing the 2bfuntex innovation approach, two methodologies were introduced and used to tackle the complex system of the 2bfuntex environment. systems thinking was used to reveal the underlying characteristics and relationships of systems, while methods of foresight helped to build medium and long-term visions of development of the science, technology and innovation, its policy, directions and priorities as well as supporting network activities.   
  
the task was workshop based: each workshop brought together the appropriate consortium partners and innovation actors. each workshop delivered a new enhanced version of the common understanding of interactions and scenarios, including adjusted guidelines for the information survey.   
  
during the project, six complexity and foresight workshops were organized:  
1) 7 - 8 february 2012, ghent, belgium: the objective was to create a common understanding of the work to be accomplished within the 2bfuntex project among the project partners. a first version of the 2bfuntex innovation model was developed. the results were documented as deliverable 1.1 âreport on first complexity and foresight workshopâ.  
  
2) 11 - 12 june 2012, zadar, croatia: the aim was to build a common knowledge based on the expected benefits and procedures of a stakeholder-based foresight process among participating partners. important topics and key stakeholders were identified to be included in the next workshops and events.  
  
3) 7 â 8 january 2013, eibar, spain: this workshop focused on exploring potential application scenarios with a clear industry perspective. six members of the industrial advisory board (iab) presented their insights and voiced their expectations as âindustry success criteriaâ for 2bfuntex.  
  
4) 28 - 29 may 2013, istanbul, turkey: this workshop aimed at âaction planningâ of three of the eight multidisciplinary teams. a special working session on building framework scenarios was conducted.  
  
5) 1 â 2 april 2014, brussels, belgium: one of the main tasks in this workshop was to focus on near-to-market technologies that already exist and develop one break-through concept based on these near-market technologies. another task was to define one great project idea that industrial partners are likely to pick up and that can be funded in horizon 2020.  
  
6) 27 - 28 january 2015, tampere, finland: the focus of this workshop was on âmultidisciplinary teams (mdts) meet the industryâ. mdts continued to develop joint research project ideas with participating local industry and higher education representatives.  
  
a foresight process was started that finally resulted in concrete action planning for multidisciplinary teams. in the course of the project a common knowledge based on the expected benefits and procedures of a stakeholder-based foresight process among participating partners was built up. relevant stakeholders were identified and invited and further input was gained through members of the industrial advisory board (iab). science-industry knowledge gaps were identified in key application areas (health, transport, energy/building and safety), with respect to promising developments from a user-perspective, and a steep analysis (longer-term socio-cultural, technical, environmental, economic, and political trends) conducted. a common vision of the 2bfuntex project led to a strategy for realizing the vision, technology and market scenarios as roadmap and eventually resulted in action plans for mdts.   
  
a language to better understand complex environments has been developed in mit and is labelled âsystems thinkingâ. this methodology visualizes the interrelations between the many factors that define the behaviour of a complex system. two important patterns in these interrelations are reinforcing loops and balancing loops. reinforcing loops are the âenginesâ that create positive or negative growth. balancing loops are the âbrakesâ that limit the growth. in order to understand how to influence a complex environment, the identification of these loops is critical. they contain tipping points, i.e. zones where small actions may cause large effects.  
  
using the above concepts the tipping points of the 2bfuntex innovation ecosystem were identified and explored. based on this insight, the priorities of the 2bfuntex actions were optimized and additional tasks identified.  
â¢ the combination of the functional textile market, innovation actors and industry is considered to be a complex adaptive system: many agents interact and influence one another and as a result produce a difficult to predict behaviour.  
â¢ through the technique of systems thinking these interactions are modelled as cause-effect relations. this results in what is called a âcausal loop diagramâ.  
â¢ while developing the causal loop diagram, attention is devoted to discovering interaction archetypes like âlimits to growthâ, âshifting the burdenâ, âeroding goalsâ, âescalationâ and âsuccess to the successfulâ.  
â¢ a well-developed causal loop diagram makes it possible â through model interpretation or through model behaviour simulation â to better predict the future behaviour of the complex adaptive system. candidate strategies can be assessed for their impact using them as driving factors within the model.   
â¢ information gathering: deriving guidelines for information survey: what, how, with which resolution and detail.   
  
considering the results of the systems thinking, of the foresight workshops and all efforts within the other work packages of the 2bfuntex project (e.g. training modules, brokerage events) the final causal loop version resulted. the original three loops of prototyping, customer involvement and industrial growth were confirmed. the expected outcomes of the project were defined more precisely. this particularly relates to the foresight process, which is a methodology rather than an outcome. the three major final outcomes of the 2bfuntex project ultimately are:  
â¢ outcome 1: the 2bfuntex website as open innovation platform  
â¢ outcome 2: industrial uptake  
â¢ outcome 3: multidisciplinary teams  
  
2bfuntex vision and strategy  
based on the results of the systems thinking and foresight workshops, the vision and strategy for the 2bfuntex project was developed by the steering group of work package leaders. it was subsequently validated by the project partners and complemented by identifying key stakeholders.   
vision  
1) we need to narrow the gap between different research areas before we can close the gaps between academic research and industry. the textile sector is a conservative/traditional sector compared to e.g. biotechnology, pharmaceutical industry, etc.. there is a gap between new developments in e.g. chemistry and textiles. we should first narrow this gap, amongst others by inviting experts from other fields to collaborate with us in the multidisciplinary teams.  
2) technologies need to be appraised before they can be transferred to industry. the technologies should be available, transferable and upscalable. we need to find a way to transfer the technologies available in research organisations to industry. for this we need a clear vision on which technologies are available that can be upscaled and transferred to industry on a short term, taking into account the value chain aspect.  
3) we need to create awareness, provide state-of-the-art on key technologies. there is a need to educate other sectors how they could use textiles, e.g. provide them with complimentary knowledge by demonstrations of best practices or proof-by-example, etc.  
4) try to match existing technologies with textile industry needs, in order to save time and money. instead of immediately starting new research to solve the textile industry needs, we should first look which technologies available in other sectors could be useful. this should be done within the multidisciplinary teams. if no appropriate technology is available, new research projects should be started to find a solution for the industrial needs.  
5) creation of a community of experts/contact points on functional textiles (for the whole value chain). the 2bfuntex community should be the unique contact place for industry and other stakeholders looking for information on functional textiles.  
  
strategy  
the following measures compose the 2bfuntex strategy to realize the vision:  
1. collect the core competences and cross sectoral activities/partners of each 2bfuntex partner.   
2. identify transferable technologies, e.g. by looking for proof-by-example and through the 2bfuntex open innovation platform.  
3. organise educational activities/workshops (also skills developing/trainings, capacity building).   
4. organise brokerage events. start-up multidisciplinary teams with a focus on specific topics.   
5. a community of experts will be the end result of 2bfuntex.   
  
scenarios to meet industrial needs  
during the workshops the participants also collected information on interesting markets, sectors and technologies such as:  
â¢ sportswear textiles  
â¢ protective textiles and clothing  
â¢ building and construction textiles  
â¢ light-weight composites (transportation)  
â¢ medical/biomedical textiles   
â¢ chemical industry (esp. as supplier)  
â¢ agricultural textiles  
â¢ home textiles  
â¢ geotextiles  
â¢ industrial laundry  
â¢ filters / nonwovens  
â¢ special / innovative fibre manufacturing  
  
partners suggested to prioritize transportation textiles and special fibre manufacturing and pointed out strategic trends such as energy saving techniques, biobased or recycled materials and use of nanoparticles in textiles. finally, âgrand' societal challenges served as âframeworkâ scenarios to investigate how to tackle these in the different sectors.  
in order to increase customer involvement, it is necessary to identify the needs of different customer groups, as customers can be different industrial sectors or direct end-users. a matrix was prepared with different types of customers and their specific needs. this information is included in deliverable d1.8 âfirst reports per envisaged areaâ and is also available for download on the 2bfuntex open innovation platform as a presentation on âtrends and analysis of industrial needs in functional textilesâ given at the 2bfuntex final conference.  
  
roadmapping and action planning  
the next step within the 2bfuntex foresight and complexity approach was to address societal and industrial needs by roadmapping possible solutions and concrete action planning.   
roadmapping  
the 3rd foresight & complexity workshop focussed on exploring potential application scenarios with a clear industry perspective. six members of the industrial advisory board (iab) presented their insights and voiced their expectations as âindustry success criteriaâ for 2bfuntex. they also actively participated in identifying science-industry knowledge gaps in key application areas (health, transport, energy/building and safety) as to promising developments from a user-perspective. this simplified âroadmappingâ exercise allowed to identify research gaps as âpathwaysâ for providing promising novel solutions for industrial needs.  
  
conclusion  
over the course of the 2buntex project, the six 2bfuntex foresight & complexity workshops served as a face-to-face platform to enhance industry-academia coordination and collaboration. they contributed to a better understanding of state-of-the art research approaches and identification of joint research and development (r&d) ideas with participating industry representatives.  
foresight and complexity methods were instrumental for identifying and supporting the eight 2bfuntex multidisciplinary teams (mdts) in developing their competitive r&d profile e.g. by developing medium- and longer-term critical success factors:  
â¢ mdt nanotechnology   
â¢ mdt electrospinning  
â¢ mdt plasma  
â¢ mdt flame retardancy   
â¢ mdt antimicrobial textiles  
â¢ mdt sustainable textiles   
â¢ mdt biotechnologies  
â¢ mdt smart textiles  
detailed information on ...

# BABYCARESLEEP

Project Acronym: BABYCARESLEEP

programme & topic: FP7-SME SME-2013-1

Most frequent returning words in objectives:

* ('system', 62)
* ('baby', 43)
* ('sids', 34)
* ('risk', 27)
* ('sensors', 24)
* ('vibration', 23)
* ('mattress', 22)
* ('sleep', 22)
* ('breathing', 21)
* ('figure', 21)
* ('babies', 20)
* ('parents', 17)
* ('control', 16)
* ('situation', 15)
* ('infant', 15)
* ('temperature', 14)
* ('infants', 13)
* ('actuation', 12)
* ('detect', 11)
* ('apnoea', 11)
* ('sensor', 11)
* ('arousal', 10)
* ('textile', 10)
* ('posture', 10)

executive summary:  
babycaresleep project has developed a novel non-invasive intelligent system to prevent sudden unexpected death in healthy infants and an early detection of risky situations. integrated into the babyâs cot through biosensing textiles, three matrices of sensors will measure relevant biological parameters: ph sensors for gastroesophageal reflux episodes, temperature sensors for hyperthermia (fever) and movement sensors to detect movement and breathing. these biological signals enable the system to detect potential risk situations and, thus, perform the preventive actions: promoting a subcortical arousal through micro-vibrators embedded in the mattress, to re-activate babyâs breathing without the need of awaking the baby.   
   
the baby care sleep algorithms for actuation have been developed in trials with 28 new born babies and validated with 6 babies from a different sample, after the development and integration of the different parts that constitute the overall system. besides, the system has demonstrated its suitability in real-home context. the system has been lent to a family for 15 days.  
the baby care sleep system consists of 5 exploitable results:  
r1: smart real-time biosensing textile: a textile layer with a matrix of sensors providing the measurements of temperature and movements (respiration).  
r2: intelligent control system: the system with the communication electronics, capable of reading the sensors and providing the actuation to the vibrators.   
r2: management and control interface: a mobile app that allows the parents consult the status of the mattress sensors and provides an alert in case of detecting a risk situation.  
r4: risk assessment and actuation algorithm, providing the guidelines for the actuation of the system in case of apnoea detection.  
r5: baby care sleep integrated system: integrates all of the sub-components developed in the project into a single product, providing the full capabilities of the system.  
  
project context and objectives:  
increasing number of women deferring childbearing and by multiple births linked with fertility treatments. as a result, there is an increased risk of neonatal deaths, which has contributed in some countries to a leveling-off of the downward trend in infant mortality rates. in europe, the prevalence rate of premature birth ranges from 5.5% to 11.4% - an average of 7.1% of all live births that means around 385 thousand of premature babies per year. furthermore, approximately 1% infants who weigh less will die of sids. for a baby who is born prematurely but who weighs more than 1.58 kg the risk of sids is less but still ten times higher than the overall rate (approximately four in 1.000).  
causes of sids deaths  
sids happens when babies are asleep and newborn babies spend 15 hours per day sleeping. in fact, the term sids refer to infants who die in their sleep with no evidence of accidental asphysia, inflicted injury or organic disease. sids is a multifactorial syndrome mainly related to overheating, prolonged apnea, gastroesophageal reflux or inadequate bedding system and posture. according to the triple risk model, sids results when three factors simultaneously influence the infant: (a) an underlying vulnerability in the infant, (b) a critical developmental period, and (c) an exogenous stressor, e.g., hyperthermia. in this model, such exogenous stressors are postulated to induce asphyxia, hypercapnia, and hypoxia.  
a failure to arouse is also one of the causes of sids, if babies stop breathing during sleep; as a defence mechanism, they usually arouse and start breathing again. in effect, they revive themselves. however, if the baby does not arouse in time -fail to wake up and take a deep breath to end a prolonged apnea-, there is a second line of defense, gasping [6]. the infantâs brain stimulates slow, deep, labored breaths that temporarily restore his oxygen supply. if this mechanism also fails, the infant will die from a lack of oxygen. the importance of arousal mechanisms related to sids is postulated by several reports. in fact two studies have provided evidence of decreased spontaneous arousals during sleep in sids compared with control infants.  
prevention of sids deaths is still an unsolved need  
current solutions do not effectively prevent sids deaths in home environments because either they are very invasive and complex such as electrocardiogram or they are too simple (only measure movement) generating many false positives (false alarms). these last lead the parents to just disconnect the system because they only perceive an increase in their stress and anxiety but not an increase in their baby safety. in addition, existing simple systems alarm parents but do not provide any recommendation. this increases even more the parentsâ anxiety when parentsâ concern for their childâs safety has augmented, also heightened due to the increased incidence of pre-mature births.  
in this context, our project has developed an innovative system integrated into a cot to effectively get babies safe and reduce the risk of sids. this product satisfies a societal need and a parentsâ demand being a good niche for innovative smes that will strength their competitive position facing foreign competition.  
concept  
babycaresleep project has to developed a novel non-invasive intelligent system to prevent unexpected death in previously healthy infants and an early detection of risky situations. integrated in the cot through biosensing textiles, three types of sensors detect the most relevant biological parameters: ph sensors detect gastroesophageal reflux episodes, temperature sensors detect hyperthermia and movement sensors detect breathing. these biological signals enable the detection of potential risky situation and perform preventive actions activating a personalized and calibrated vibration system. the preventive actions are be comprised by early-warning advices to parent and by a system that stimulates sufficiently the babyâs instinct to breath (generate a sleep arousal) avoiding infant's hypoxia and resuming breathing activity. in addition, this system is so gentle that doesnât awakes the baby from sleep.  
therefore, the product is composed of the following features:  
\* real-time measurement of main sids risk factors through biosensing textiles: ph related to gastroesophageal reflux, pressure related to breathing & movement, and body temperature related to hyperthermia.  
\* intelligent control system performing the following functionalities: (1) risk assessment of sids according to the different thresholds and real-time measurements of the biological signals. (2) implementation of different actuation strategies once the risk situation has been detected and (3) recording the data for a paediatrician assessment.   
 - personalise the actuation strategies according to: (1) the specific characteristics of each baby: their corrected age and the fact of being new-borns or not (2) parent needs and.  
 - risk assessment into the following levels:  
 . detection of a potential risky situation related to gastroesophageal episodes, hyperthermia or an excessive number of apneas (yellow alert). in this case, the system informs and advice the parents to perform some corrective actions (early-warning advices). timing and way for information and advice will be related to the level of risk for each case, e.g. if an excessive number of gastroesophageal reflux episodes are detected, the advice of tilting 30âº upward the upper part of the mattress for the following days will be giving the next morning.  
 . detection of an imminent risky situation (orange alert): an excessive prolonged apnea. in this case, the system activates the vibration system to stimulate an arousal and resume breathing without awaking the baby.   
 . detection of an emergency (red alert): failure to arousal and resume breathing after the activation of the vibration system. in this case, an immediate alarm to the parents will be sent including recommendations or advices of action to perform.  
\* sleep monitoring: a record containing the main events related to measured biological signals will enable a further assessment by a paediatrician if needed or recommended by the babycaresleep system.   
 - actuation systems for sids prevention that will be integrated into the cot composed by:  
 . vibration system: the level of vibration will be also personalised according to the babyâs specific characteristics.  
 . mechanical actuators, that will aid some manual action that the parent will need to perform according to recommendations of the risk assessment system, namely, the parents will need to tilt 30âº upward the upper part of the mattress in case of some risky situation.  
 - management and control user friendly interface that will enable the personalization and control of the system, the visualization of the recorder signals and the detected risky situations together with some preventive advices if the preventive actions should be implemented by the parents. this interface will be wireless and a simplified version will be developed for smartphones.  
scientific objectives  
1 characterization of the sleeping system for newborns in order to prevent sids.  
2 characterization of a model for babyâs breathing based on abdominal and thoracic pressures that will estimate the breathing rate adapted to different newborn profiles.  
3 determination of the vibration patterns (axis of vibration, frequency, duration and amplitude) to resume breathing in case of a too prolonged apnoea without awaking the baby from sleep.  
4 determination of accuracy and resolution for each physiological parameter to detect sids risk factors.  
5 develop the algorithm for sids prevention that will show the logic for detecting a risky situation and performing preventive actions (warn & advice parents or activate the personalized vibration pattern)  
technical objectives  
6 selection and integration of the optimal sensor to measure ph of baby reflux based on the following parameters: robustness, reliability, range, resolution, cost, embedding difficult, power consume, re-use, safety and resistance to human fluids.   
7 selection and integration of the optimal pressure sensor (adapted to the low babiesâ weight) to measure breathing and movements based on the following parameters: robustness, reliability, range, resolution, cost, embedding difficult, power consume and safety.  
8 selection and integration of the optimal sensor to measure body temperature without skin-contact based on the following parameters: washable, robustness, reliability, range, resolution, cost, embedding difficult, power consume, re-use and resistance to human fluids.  
9 develop a sensor matrix with smart textiles (number of sensors, distance and distribution in zones depending on the biological sensor that is measured) to detect sids risk in a robustness and reliability way.  
10 develop a vibration system with stimulation ranges (pulse frequency, duration and amplitude) that cover heterogeneity of babies from 0 to 8 months old  
11 embedded sensors, vibration and communication system on the cot to ensure correct sensors interaction without interferences and patient comfort.  
12 develop a wireless intelligent control system and a user-friendly interface to detect the risk factors, to manage the warnings and to perform the preventive actions.   
integrated objectives  
13 integrated mechanical preventive actuators  
14 integrate babycaresleep solution on a cot.  
15 validate the effectiveness of babycaresleep prototype with 6 healthy babies and simulators using it during 2 hours  
16 usability of the final system with 20 parents.  
  
project results:  
r1 smart-real time biosensing textile  
the textile sensor allows the following objectives:  
â¢ measuring respiratory rate and the absence of breathing of the baby to detect an apnea.  
â¢ measuring the skin temperature of the baby.  
a prototype cover mattress has been produced with the optimal sensors for the application (figure 1).  
in this construction, the major material is polyester selected for its low cost and validation for use in health and medical products. the copper yarn is insulated with a strong layer of polyurethane to avoid any contact. the open and lightweight structure offers a better comfort with thermal regulation and fits with the babykeeper mattress concept: no fluid retention but allows pass-through.  
   
figure 1. schematics of the cover matrix for the textile biosensing layer.  
  
the given pattern for the copper is taken in the weave pattern with polyester but every 2 cm the yarn makes a float. that means the yarn is not taken to make a loop on the top of the textile surface. that pattern was made to facilitate the connection to the sensors. with that construction, we can easily catch the yarn and solder it to the different sensors.  
the copper yarn placement has been designed to allow the integration of temperature sensors in a way that they cover all the area. if the babyâs head is in contact with the mattress on a round shape having a diameter of min. 6 cm, then we are sure at least one sensor is covered by the head. this is how we decided to have a space of 4 cm between each pair of copper yarns.  
these dimensions should allow to fully cover the mattress area, and also to get 10 cm of textile available on each edge to attach it and connect the matrix to the electrical box. a special beam has to be prepared for this sample as we need copper yarns in both directions (figure 2)  
since the breathing sensors are directly woven in the cover, it is necessary a first network to acquire the breathing signal from the most efficient place (according to the baby position). the signal is read in the blue little circuits (figure 3) and transformed to be transferred from the mattress to the control box. the breathing sensors are represented in red. each blue square is a small oscillator circuit that connects to the copper wire and is encapsulated in silicone to ensure robustness and waterproofness.  
   
figure 2. the textile biosensing layer over the breathable mattress.   
  
in addition to this breathing network, there will be a second network for temperature measurement. each little temperature sensor (figure 3) is soldered to a horizontal wire and a vertical wire. so, the temperature can be read at each point through to a multiplexing system located on both sides of the mattress.  
   
figura 3. schemantics of the textile layers with the temperature sensors on top.  
  
r2. intelligent control system  
the mattress sensors and actuators are connected to the sensor control box which is designed to attach to the babyâs cot and provide the primary interface between the sensors and the pre-installed house wi-fi network. the sensor control box takes the raw temperature and breathing signals and provides signal pre-conditioning to turn the raw signals into sensible digital data that can be interpreted by the algorithms being developed and results communicated to the smartphone application.  
electrical power is used to operate the sensor control box, nonetheless it is connected via a medical approved low voltage power supply unit (en 60601-1) to ensure that the mattress system is maintained isolated from any potentially harmful voltage sources.  
   
figura 4. electronic board for the control of the biosensig textiles of the mattress and the communication.  
  
r3. risk assessment and actuation algorithm  
the risk assessment and actuation algorithm determines the strategy and the responsiveness of the system.  
the main inputs of the system are the smart--real time biosensing textile, and the outputs are the vibration system and the management and control interface.  
the overall cycle of risk assessment and actuation defines three different states of alert (figure 5):  
1. imminent risky situation.  
2. emergency.  
3. advise scenario.  
these three states depend on the measurement of the sensors and the reaction of the baby.  
   
figure 5. algorithm for risk asessment and actuation, the three states of alert are shown in colours. yellow for risk if an apnea is detected, red for emergency if besides the detection of the apnea there is no reaction in the baby, and finally the advise, where the events are shown to the parents.  
  
the first state imminent risky situation raises when an apnoea duration of 10 seconds or more is detected. this state triggers the vibrator that will try to produce a sub--cortical arousal without awaking the baby. if the breath is detected after the vibration, the system recovers to the rest status and produces an entry in the log of the system.  
the depth of the vibration depends on the characteristics of the baby, and will be specified later.  
if the baby is still in apnoea after the vibration, the system enters in the state of emergency.  
the aim of this state is to end the apnoea of the baby as soon as possible. therefore, the system, in parallel will raise an alarm to advice the parents, and will be set in continuous vibration at maximum level.  
whenever the system is set to the imminent risky situation or the emergency, it records an event in the log of the system.  
the caregivers of the baby can consult the log of the system in order to assess the sleep of the baby. this is the advise scenario.  
this state is interesting to check if any apnoea has occurred during the sleep of the baby, and to verify the responsiveness of the system.  
false positives  
the algorithm of the system has been prepared to reduce as much as possible the inconveniences due to the false positives.  
most false positives occur in the imminent risk situation where the system should be able to deal with the situation in many cases.  
the side effects of false positives could be an awakening of the baby, and the subsequent discomfort for the caregivers. to reduce this possibility, the level of vibration can be set--up to produce a sub--cortical arousal without awakening the baby.  
uncomfortable false positives can also be produced if the system raises an alarm. the main source of alarm related false positives are due to the sleeping posture: when the baby is sleeping in a side posture, the baby care sleep system could not detect the respiration and the possibility to produce an arousal is smaller, but at the same time, this posture is not recommended for the paediatricians as it is a risk posture.  
determination of the vibration level  
the right level of vibration to produce a sub--cortical arousal avoiding at the same time an awakening has been determined through an experiment in which 28 babies between 2 and 8 months took part.  
the validation of the model has been done with 6 extra babies with the same conditions of the babies participating in the initial study. just one awakening has been produced in the sample of babies for the validation.  
the level of vibration is determined by the duration of the vibration cycle, the intensity applied to the vibrators and the rest between cycles.  
the selection of the vibration level depends on the babyâs sleep posture, age and gestational age.  
with respect to the sleeping posture, it should be a supine posture for the correct performance of the system. besides, this is the only posture recommended by paediatricians.  
for younger babies (figure ), the vibration level can be milder. according to the model validated in the project, the decision tree (figure ) according to these values is efficient in producing sub--cortical arousals avoiding awakenings.  
therefore, when used correctly, the baby care sleep system will be able to manage most of the situations related with apnoea, minimizing the need for caregivers to attend the baby.  
   
figure 6. algorithm for the selection of the vibration level. the algorithm depends on the corrected age and the gestational age of the mother and requires the baby sleeping in supine position.   
  
r4. management and control interface  
an android application has been developed for the baby care sleep (figure 7).  
   
figura 7. splash screen for the baby care sleep android application.  
the application contains recommendations to prevent sudden death infant syndrome (figure 8). the purpose of the recommendations is twofold: on one hand it provides a repository of good practices to the parents and the caregivers of the baby, on the other hand, the possibility to be downloaded for a repository for public domain information, it provides an outcome for curious people as long as they are able to know the good practices and gather information about the baby care sleep product.  
   
figure 8. example screen of the recommendations.  
the app allows the communication with the mattress through a domestic wifi network. to achieve this there is no need for a particular interface in the mattress, in order to keep the hardware as simple as possible. the only thing to be done is pressing the set-up button of the mattress (figure 9), and then using the configuration menu of the app, and the wifi configuration is passed to the hardware of the mattress (figure 10).  
this is achieved through a temporary wifi network created by the hardware of the mattress. the app will look for this temporary network and will use it to pass the information of the permanent wifi network to be used.  
   
figure 9. the button to force the set--up mode in the hardware prototype of the mattresss.  
   
figura 10. the connection screen of the android app. the configuration of the wifi network is passed from the app to the mattress hardware through the use of a temporary wifi network   
  
once the system is properly configured, the app can receive information from the mattress and the parents and caregivers can consult the information on--line.  
the app is ready to manage information related to the body temperature of the children, the breath rate and the ph (related to the presence of threw--up of the baby) (figure 11).  
   
figure 11. the app can receive information from the mattress and can display charts of the evolution of the information. the example picture shows a chart with the evolution of the temperature (with sham data).   
  
besides, the app allows the analysis of the log record of the system.   
the log is especially important for the analysis of risks: the situations where the baby care sleep found a possible apnoea reacted and dealt properly with the situation. this analysis can provide parents useful information and help the clinicians to understand the real status of the baby.  
alert occurs when the system detects an apnoea and it is not able to properly face the problem. it is a potential dangerous situation for the baby.  
when an alert occurs the system keeps the stimulation at maximum and the smartphone app raises an alarm informing the parents or carers of the baby (figure 12).  
   
figure 12. screenshot of an alarm. an emergency alert is shown to parents or carers.  
  
r5. babycaresleep integrated system  
the integrated system provides a unified framework for all the above commented results. despite, all results have separated exploitable characteristics, the integrated system has a unique value of providing a unified structure to face the problem.  
besides, when a potential harmful situation is detected, the systemâs actuation algorithm applies the micro-vibrations to elicit the micro arousals of the baby.  
  
potential impact:  
socio-economic impact  
sudden death infant syndrome (sids) is the highest cause of death in the post-neonatal period (between 2nd and 6th month of life). only in europe, each year 2400 infants still die of sids (about 3000 in usa), according to the international society for the study and prevention of perinatal and infant death. furthermore, as infant mortality has decreased in last decades, sudden death infant syndrome has increased in importance among other death causes.  
this syndrome is ten times more frequent in preterm infants and occurs more frequently in infants who have had apparent life-threatening events (altes) ---approximately 7 percent of infants who die from sids have a history of altes--- and in siblings of infants who died of sids.  
nowadays, the number of preterm births has tended to increase. this tendency is caused by an increasing number of women deferring childbearing and by multiple births linked with fertility treatments. as a result, there is an increased risk of neonatal deaths, which has contributed in some countries to a leveling-off of the downward trend in infant mortality rates. in europe, the prevalence rate of premature birth ranges from 5.5 to 11.4% - an average of 7.1% of all live births that means around 385 thousand of premature babies per year. furthermore, approximately 1% infants who weigh less will die of sids. for a baby who is born prematurely but who weighs more than 1.58 kg the risk of sids is less but still ten times higher than the overall rate (approximately four in 1,000).  
sids happens when babies are asleep and newborn babies spend 15 hours per day sleeping. in fact, the term sids refer to infants who die in their sleep with no evidence of accidental asphyxia, inflicted injury or organic disease. sids is a multifactorial syndrome mainly related to overheating, prolonged apnoea, gastroesophageal reflux or inadequate bedding system and posture. according to the triple risk model, sids results when three factors simultaneously influence the infant: (a) an underlying vulnerability in the infant, (b) a critical developmental period, and (c) an exogenous stressor, e.g., hyperthermia. in this model, such exogenous stressors are postulated to induce asphyxia, hypercapnia, and hypoxia.  
a failure to arouse is also one of the causes of sids, if babies stop breathing during sleep; as a defence mechanism, they usually arouse and start breathing again. in effect, they revive themselves. however, if the baby does not arouse in time ---fail to wake up and take a deep breath to end a prolonged apnoea---, there is a second line of defense, gasping. the infantâs brain stimulates slow, deep, labored breaths that temporarily restore his oxygen supply. if this mechanism also fails, the infant will die from a lack of oxygen. the importance of arousal mechanisms related to sids is postulated by several reports. in fact two studies have provided evidence of decreased spontaneous arousals during sleep in sids compared with control infants.  
in principle, the parents of each one of a newborn could be a potential buyer of the babycaresleep system in a long-term scenario. so, our long-term global market could involve yearly around 5.4 million babies per annum, this is the number of children born each of the last three years for which data are available (2008-2010) in the eu-27.  
nevertheless, sids is ten times more frequent within preterm newborns, higher even in case of a extremely preterm [6]. this is the reason why we consider preterm newborn as our potential market for babycaresleep system. in europe, the prevalence rate of premature birth ranges from 5.5 to 11.4% depending on the county; an average of 7.1% of all live births that means around 385 thousand of premature babies per year.  
in addition, number of preterm births is increasing every year. this trend is caused by an increasing number of women deferring childbearing and by multiple births linked with fertility treatments. one in six couples worldwide experience some form of infertility problem at least once during their reproductive lifetime. the current prevalence of infertility lasting for at least 12 months is estimated to be around 9% worldwide for women aged 20-44. as a result, there is an increased risk of neonatal deaths, which has contributed in some countries to a leveling-off of the downward trend in infant mortality rates.  
  
list of websites:  
www.babycaresleep.com

# TEXSET

Project Acronym: TEXSET

programme & topic: FP7-PEOPLE FP7-PEOPLE-2013-IEF

Most frequent returning words in objectives:

* ('textile', 22)
* ('research', 10)
* ('tools', 8)
* ('experimental', 8)
* ('project', 6)
* ('ancient', 6)
* ('museum', 6)
* ('rome', 6)
* ('textiles', 5)
* ('texset', 5)
* ('archaeology', 5)
* ('analysis', 5)
* ('museums', 5)
* ('laurito', 5)
* ('etruria', 4)
* ('technology', 4)
* ('objective', 4)
* ('production', 4)
* ('objects', 4)
* ('centre', 4)
* ('university', 4)
* ('conference', 4)
* ('italy', 3)
* ('period', 3)

texset-project. textiles in southern etruria. textile technology in central tyrrheanian italy from late prehistory to the etruscan period  
  
the texset project has investigated the emergence and development of textile technologies and the use of textile fibres in central-western italy from late prehistory (final bronze age â 10th century bc) until the etruscan period (8th-4th century bc).  
the texset project has had two objectives that follow two distinct but connected threads. the first, studying the spinning and weaving tools of the etruscan-italic world, is connected to analyses of archaeological textiles; the second has involved museological research looking at presenting scientific research in innovative and more accessible ways to inform the wider public of the importance of fabric-making activities in the ancient world. the first objective included the study of preserved archaeological textiles, textile implements and their contextualisation, as well as ancient iconographic and literary sources. the research has further integrated experimental archaeology combined with an ethnographic approach. new analytical methods for textile analysis developed in recent years were applied to explore what constituted pre-etruscan and etruscan textile tool kits and the range of qualities that could be produced by these tools. this was then compared to changes in the chronological and/or geographical record. the first objective has been to enhance our understanding of a long period of evolution in textile production, before the standardisation of technology and production in the roman empire. the second objective has been to combine the archaeological study with museological research to develop new approaches in exhibiting textile artefacts and tools in an archaeological museum context. specifically, the focus has been on how to best âtranslateâ scientific results in new ways. the objective has been to find new ways to exhibit specific objects, such as textile tools, in the national etruscan museum of villa giulia in rome and in the national archaeological museum of vulci (in the province of viterbo, north of rome).  
all objectives declared at the beginning in the application itself have been achieved.  
the first step was to create a wide network bringing together museums including the national etruscan museum of villa giulia and others under the archaeological superintendency for lazio and southern etruria, together with the centre for textile research and the national museum of denmark in copenhagen, the la sapienza university of rome, the saxo institute at university of copenhagen, and the land of legends, the experimental centre at lejre, denmark. the scientific analysis of the many fragments of fabric has been done by margarita gleba from the university of cambridge, who also includes data from southern etruria in her erc project production and consumption: textile economy and urbanisation in mediterranean europe 1000â500 bce (procon).  
textile tools from the famous necropoleis in cerveteri, vulci, tarquinia and in ager-faliscus area have been catalogued and well documented with drawings and photographs. all data have been collected and analysed following the methodologies developed at the centre for textile research.  
moreover, the experimental archaeology has played a central role in helping to understand these etruscan objects. dr. laurito has therefore launched an experimental programme which involves the lejre experimental centre and the technical-functional analysis laboratory headed by prof. cristina lemorini (chair of experimental archaeology at la sapienza university of rome). the aim of this team work was to bridge the northern and southern european experimental methodologies. we believe that the opportunity to connect different european research groups and work in an interdisciplinary way will fill gaps in understanding of the long operational chain of textile activities and propose a more comprehensive interpretation of textile tools and technology. certainly the more detailed understanding we have of these ancient everyday objects, the more useful they become for outreach and exhibition purposes. the objects have an important story to tell, and it is recounting this story which poses the greatest challenge to many museum workers and archaeologists.  
the experimental archaeology bridges the two objectives: the textile tool analyses and the way to display them in museums. during the fellowship dr. laurito visited many european museums and met curators and conservators to learn and be trained for her project in the italian museums.  
in italy before the texset project only very few fragments of textiles from pre-roman times had been identified. however, thanks to the texset project, today more than 60 textile fragments have been identified in the museums in southern etruria. this has been the projectâs first significant discovery. dr. laurito worked systematically to re-examine data from the dozens of fabrics identified in cerveteri, tarquinia, vulci, grotte di castro and narce using sem analysis in collaboration with margarita gleba. samples have also been selected for dye analysis in the laboratories of dr. ina vanden berghe (royal institute for cultural heritage, brussels). during the final international conference in rome (11-12 february 2016) an exceptional discovery has been announced to scientific community: the most ancient italian archaeological fragment of textile dyed with purple from murex shell has been identified in tarquinia by romina laurito and margarita gleba.  
the renewed interest of the italian scientific community in textile archaeology has resulted in greater attention being paid to the archaeological textiles and textile tools. this attention was manifested during the conference organized by romina laurito in rome at the danish academy on the 11-12 february 2016, where more than 25 speakers were invited to share results of their research, strictly connected to the texset research, and more than 130 persons attended the two-days conference. the conference and its publication (scheduled to 2017) represent the final communication event as planned in the application.  
the potential impact and use of dr. lauritoâs research is that the italian scientific community, mainly archaeologists and curators, know the huge potential of the textile tools in order to understand not only the textile production in ancient times but also for the investigation of ancient italian technology, economy and society.

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# TEX-SHIELD

Project Acronym: TEX-SHIELD

programme & topic: FP7-SME SME-2012-2

Most frequent returning words in objectives:

* ('project', 28)
* ('textile', 14)
* ('products', 14)
* ('materials', 14)
* ('performance', 12)
* ('water', 11)
* ('fluorine', 11)
* ('repellency', 10)
* ('pfcs', 10)
* ('tex-shield', 10)
* ('market', 10)
* ('pfoa', 9)
* ('textiles', 8)
* ('chemistry', 8)
* ('repellent', 8)
* ('pfos', 8)
* ('development', 8)
* ('work', 8)
* ('impact', 8)
* ('attendees', 8)
* ('coatings', 7)
* ('developed', 7)
* ('content', 7)
* ('industry', 7)

executive summary:  
for many years, numerous well-known brands of performance textiles have been coated with perfluorocarbon chemistry to impart highly durable oil and water repellent (dwr) properties to the textile. in the early stages of the technology, repellency was provided by simple paraffin or wax coatings, which washed out over time. following on from this, perfluorooctane sulfonate (pfos) and perfluorooctanoic acid (pfoa) are chemicals belonging to the family of perfluorochemicals (pfcs) and were developed into products which became known as 'c8 chemistry'. although pfc-c8 are used together with binders that act as glue to stick to the surface of fabrics, these are not chemically bonded to the substrate and can therefore leach out, potentially causing an environmental and/or ecological threat. in response to this, in january 2006, the u.s. environmental protection agency (epa) approached the eight largest fluorocarbon producers and requested their participation in the 2010/15 pfoa stewardship program, and their commitment to reduce pfoa and related chemicals globally in both facility emissions and product content by 95 percent by 2010, and 100 percent by 2015. additionally, pfos was added to annex b of the stockholm convention on persistent organic pollutants in may 2009. in response to these measures, the industry has developed perfluorohexanoic acid (pfha), also known as âc6 chemistryâ. although claimed to be less harmful than pfos, it is also less attractive to the end user both in effectiveness (i.e. how well the finished article repels water and/or oil) and durability ( i.e. how long the repellent effect lasts after wearing and washing).  
  
this leaves the textile and clothing supply chain, and its end users, with a problem: how to maintain established levels of performance in so-called dwr products whilst eliminating the undesirable c8 chemistry which is largely responsible for delivering the desired performance. the tex-shield project aimed to investigate potential solutions to this problem.   
  
during the early months of the project, the partners elected to investigate three categories of potential solution that would benefit not only the smes and sme-ags involved in the project, but also the wider textile and clothing supply chain. these categories were:  
1) âshorter chainâ pfc products with a view to identifying formulation and deposition parameters to yield optimum performance   
2) silicone/fluorosilicone approaches to reduce fluorine content whilst maintaining functional performance  
3) development of nano-structured fluorine free materials  
  
the full report for the tex-shield project contains an expanded discussion of the results of each of these approaches. although the ultimate goal of a pfc-free durable water repellent treatment for textiles is yet to be attained, the deeper understanding of the complexities of the subject obtained and the advances made during the tex-shield project has brought that day closer.  
  
project context and objectives:  
durable water and/or oil repellent treatments on textiles work by reducing the tendency of liquids to spread out and penetrate the fibres on contact with the substrate: instead, the liquid maintains a high âcontact angleâ with the substrate. the repellency finish allows liquids to bead up and roll off the fabric, or liquid spills to be easily wiped away with a clean cloth. thus, their usefulness in, for example, keeping skiers dry in heavy snowfall, or soft furnishings serviceable after food or drink spillages, is a highly desirable added-value attribute for the finished article.  
  
the current fluoropolymer-based stain repellent treatments are known to pose significant health concerns. pfcs are either produced by electrofluorination or teleromerisation, manufacturing processes which give out unintended by-products of perfluorooctane sulphonates (pfos) and perfluorooctanoic acid (pfoa). pfoa has the molecular formula c8f1502h while pfos is c8hf17o3s.  
  
during service life, the pfc treatment is gradually leached from the fabric, and decomposes to pfoa and pfos. both pfoa and pfos are very stable in the environment and, hence, are a significant ecological threat, as the levels reached in higher organisms (including people) can become significant. consequently, the u.s. environmental protection agency (epa) and some of the biggest fluoropolymer manufacturers have cooperated in studies and have collected and shared their findings. the following results have been highlighted from this research about pfoa and pfos:  
â¢ they are very stable in the environment, so they do not readily degrade.  
â¢ once they enter the human body they are eliminated very slowly. this means that they remain in the body for relatively long periods of time: the half-life in humans is about 4.5 years.  
â¢ they cause adverse effects in laboratory animals that have been given high doses over a long period of time.  
  
to put the project into economic context, the european commission identified personal protective equipment (ppe) as a âlead marketâ (defined as a market which presents âa significant potential for global market leadership by european companies based on important scientific and technological developments achieved by european researchersâ) also, the annual sales value of the outerwear market in the eu was estimated to be over â¬10 billion in 2012 (source: european outdoor group âstate of tradeâ report http://tinyurl.com/jox6nfu ). of this figure, 42% was defined as âouterwear topâ and a further 12% as âouterwear bottomâ garments. it is likely that a substantial percentage of these sales are for dwr products, which reinforces the importance of finding a suitable alternative to c8 chemistry. there is also significant demand for water and oil repellent garments (particularly in the ppe trade, which had a worldwide wholesale value of us$9.92 billion in 2014) and in soft furnishings (especially in the hotel trade), both of which have historically relied heavily on c8 chemistry to impart desirable characteristics to the finished product.  
  
it can be readily seen that there is significant market demand for the dwr family of products, and the tex-shield partnership is well placed to exploit any new technology developed by the project, consisting as it does of end users (eva commerce and panaz), and sme-ags with outdoor wear, ppe and contract furnishings businesses amongst their membership.   
  
in addition to the global details given above, a survey of smes throughout europe was undertaken by the project team to provide guidance on the requirements placed on new repellent coatings from an industrial perspective. in summary, the respondents were clear that they required high performance repellency for water and oil, but, surprisingly, retention for 5-10 washes was seen as adequate, with little requirement for considerably higher durability.   
  
  
the key objectives of the project were to investigate means of:  
1) eliminating problems with c8 pfcsâ by-products associated with textile treatments.  
2) providing a cost-effective alternative treatment which allows textiles to be provided with durable anti-soiling/anti-staining characteristics.  
3) reducing the total fluorine content in the treatment by means of new sol-gel derived additives in the form of nanoparticles or inorganic-organic hybrid networks.  
4) demonstrating performance on a representative scale, with regards to key technical parameters including soil resistance, abrasion resistance, cleaning cycle resistance.  
5) creating additional advantageous functions such as anti-static and anti-microbial characteristics to improve stability against mechanical, chemical impacts.  
6) developing flexible and versatile solutions for a broad range of textile supports different in structure (woven, knitted) and basic fibres (natural, synthetic or mixtures).  
7) developing a solution with a low ecological footprint, based on reach-proof chemicals and taking into account safety and health issues.  
8) providing a full life cycle analysis (including washability cycle) and assessment of techno-economic benefits, via benchmarking against current products.  
9) providing the necessary technological transfer and training via sme associations to ensure awareness and take up throughout the ec.  
  
project results:  
our work gave us a unique understanding of candidate alternative methods to confer water and oil repellency to textile fabrics. this led us to conclude that, in the short to medium term at least, industry standard replacement of pfc-c8 chemistry is most likely to come from shorter chain pfcs â either pfc-c4 or, most probably, pfc-c6. whether these alternatives will be acceptable in terms of environmental legislation remains to be seen. the german chemistry business rudolf chemie claimed in an issue of the magazine textile insights (february 2009) that âc6 is closest chemically to c8, but it contains no pfoa. it breaks down in the environment.â  
investigations into fluorine-free approaches led us to believe that the required standards of oil and soil repellence cannot be attained via non-fluorinated chemistries: some fluorine is likely to be required to produce an acceptable performance. on this basis hybrid systems such as fluoro-silicones may well offer promise as âcomposite approachesâ, containing reduced fluorine content but offering high water repellence with good handle and durability.  
  
nanotechnology is another option: this appears to be a promising approach and the industry has developed innovative methods to deliver the required performance. however, the long-term effect of this technology on the environment is not clearly understood.  
  
the coatings that have been developed and evaluated through this programme were intended to replace the incumbent materials but designed in such a way that the environment would be more tolerant toward them. to achieve this three approaches were followed:  
  
1) fluorocarbons with carbon chains smaller than eight.  
2) a polysiloxane loaded with silica nanoparticles.  
3) a completely fluorine-free nano-silica functionalised to provide repellency whilst binding to textile fibre surfaces.  
  
of these, approach 1 can be considerd as being closest to market as it was exploring the use of commercially available materials, such as c6 pfc. however it was established during this project that these shorter chained pfcs do not give comparable performance to the c8 pfcs. this implies that either the applications will have to accept a reduction in properties or the coatings will have to be boosted in some manner. this approach does offer a reduction in the perfluorocarbon content on fabrics and garments and reduces the environmental impact. the approach of a direct replacement of c8 by c6 perfluorocarbons also would fit with existing processes currently used in the textile industry. this means that energy and waste expenditure would be similar to current systems but with a reduction in the environmental impact caused by the c8 fluorocarbons.   
  
the second approach again uses commercially available materials although the specific materials are not currently used within the textile industry. these were siloxane polymers and silica nanoparticles that when combined were able to be applied and cured onto textile. these materials are fluorine-free and therefore fundamentally more environmentally friendly than the incumbent products. they were found to provide water repellency, which for some applications would be suitable for use in the textile industry.   
  
however, the repellency to oil (oleophobicity) was not as good as the incumbent c8 perfluorocarbons. during the course of the project, attempts were made to improve the oil repellency, but that required the development of a novel post treatment that required a high temperature process and was also fluorine based, although smaller than the c8 fluorocarbons. it should also be stated that despite the post treatment, the level of oleophobicity was not still not comparable to the c8 pfc materials and so would require further development work before commercial trials were possible.   
  
using surface energy and contact angle measurements on model materials, the third approach demonstrated that by using functionalised nano-silica it should be possible to obtain a coating that had superhydrophobic and oleophobic properties without any fluorine content this approach is still at the lower technology readiness levels and requires further product development before it could be considered for market evaluation.  
  
the information gathered and subsequent calculations undertaken during the project show that the environmental impact of the materials in development will reduce the fluorine content of fabrics, with several approaches completely removing fluorine from the systems. with the exception of the uv cure process, all of the approaches discussed have been designed to fit with existing practices within the textile industry. the environmental impact of processing of these materials is mainly governed by the curing processes rather than the components or manufacture of the coatings themselves. the curing process can be improved in a number of ways, for instance by increasing packing efficiency as material is pushed through the ovens, or improving the efficiency of the oven, reducing cure times and temperatures, but these are outside the scope of this project, although the cure time is in some ways begun to be addressed with the uv cure system.  
  
  
although the ultimate goal of a pfc-free durable water repellent treatment for textiles is yet to be attained, a number of promising routes have been explored and represent valuable progress towards the goal of reducing fluorine in coatings that would be suitable for technical textiles whilst still retaining the desired repellency performance. this has included materials and processes which can be implemented immediately such as the c6 chemistries boosted with paraffin wax or cyclodextrins.   
  
cyclodextrins were also shown to boost the performance of c4 pfcs. the sol gel system of nano-x, boosted with paraffin wax also performed well, although the inference from some characterisation performed on this system suggests that the nano-x materials may not actually be sol gel. this is surprising and further work will be required to verify this.  
  
the application of very thin coatings of c6 pfcs by plasma was also thoroughly explored and holds promise for some applications, especially where repeated washings are not a requirement.  
  
a water-borne uv curable system has been developed using commercially available materials, which showed good repellency to both oil and water. durability was further enhanced by the addition of a commercial fixative.  
  
a filled polysiloxane, again based on commercially available ingredients was developed. this was found to be superhydrophobic, demonstrating self-cleaning behaviour. this material could be made at scale, through toll manufacture, relatively quickly. attempts to improve the oil repellence of this material led to the development of synthesis routes to novel structures. further work on these is required before they could be taken forward.  
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it should be noted here that, whilst concepts have been demonstrated, further work is required to take the materials to higher trls.  
  
at the time of writing this report, the tex-shield project consortium has no applications for patents, trademarks or registered designs. one of major chemical companies in the world (huntsman) has contacted the co-ordinator with a view to arranging a conference call to discuss the results of the tex-shield project in february 2016.  
   
potential impact:  
impact on eu society  
there are a number of benefits to the eu that will result from the successful development of pfc free (or reduced pfc) dwr treatments for textiles:  
1) public health benefits - the existing pfc based chemicals â particularly c8 products - have been identified as a threat to human health. c8 pfcs have been found in the tissues, blood and foetal-cord of animals and humans. pfcs have been found to be persistent, bio-accumulative and toxic to mammalian species and also prone to cause certain cancers in laboratory test animals and are referred to as a âlikely carcinogenâ. c6 and c4 chemistry have yet to be subjected to the intense levels of scrutiny that c8 products have been, but there is a widely held belief that reducing the use of pfcs is a desirable objective.  
2) individual health benefits â it has long been established that suitable ppe can help to not only reduce industrial accidents but also reduce absenteeism from less traumatic events such as the common cold. thus, an effective dwr solution will help to reduce absenteeism in the workplace.  
3) contribution to regulatory framework - by providing a greater understanding of the science involved in dwr products, tex-shield has contributed to the elimination of hazardous chemicals detrimental to the environment and to cutting down the release of such substances into the environment. this will contribute to the ec regulation 1907/2006 (reach) that emphasizes on the safe use and disposal of chemicals and chemical substances.   
  
impact on textile supply chain competitiveness  
the eu has identified personal protective equipment (ppe) as a âlead marketâ, which offers âsignificant potential for global market leadership by european companies based on important scientific and technological developments achieved by european researchersâ. in addition to this clear advantage, outerwear is a > â¬10 billion per annum sector in the eu. many of these products derive added value from dwr finishes, and the opportunity for european producers to gain market advantage by having access to ground-breaking technology is significant.  
  
impact on participants  
the most evident potential benefit for the participants in tex-shield is in the ability to access a large market with an innovative, highly desirable product. the advantage of this has been identified by the widely respected academic robert g. cooper, who says in his book winning at new products âone of the top success factors we uncovered is delivering a differentiated product with unique customer benefits and superior value for the user.â   
  
with annual worldwide workwear sales approaching $10 billion per annum, eu outer wear sales at â¬10 billion and an estimated 17.5 million hotel rooms worldwide in 2012 (source: str global), the market for dwr products is huge. although no reliable figures exist for what proportion of these end uses involve dwr products, the absolute numbers are clearly substantial.  
  
dissemination  
internal - this includes all the actions aiming at ensuring a good diffusion of information and documentation among the project partners in order to increase the awareness. internal dissemination has been achieved through the following channels:   
â¢ private project website: the private website was set up and used to ensure for all the partners access to proper information and project progress. it was used as a database and collection for all the reports generated by each work package team as well as general project information, including all the presentations and seminars released by the project technical committee and project management boards.   
â¢ internal meetings and workshops: two types of internal meetings and workshops were used in the development of the project: conference calls and face-to-face meetings. as stated in the consortium agreement document, the regular meetings were the ones for the project steering board (psb), face to face, one every semester and the ones for the consortium conferences calls, organized quarterly. industrial partners worked on the dissemination and use activities by involving their internal product groups and r&d teams.  
  
external - external dissemination included actions aiming at ensuring the visibility and awareness of the project and the results outside the consortium. these actions were concentrated on the scientific and sme community. the focus on smes was primarily delivered by the sme-ag partners. a number of other âroutes to marketâ were also employed, including  
â¢ public project website, the tex-shield public web (http://www.texshield-project.eu) presents to the general public the objectives of the work, the organization, the partners composition, the internal and external events, and the scientific publications.  
â¢ promotional flyers  
â¢ posters  
â¢ workshops organized by the 4 sme associations  
â¢ promotional video (at the time of writing, this is being reviewed by the partners and will be uploaded to youtube in early february 2016)  
in total, tex-shield was promoted on over 80 separately identified occasions throughout the project lifetime.some notable dissemination events and approximate number of attendees were as follows:  
poster presentation, 'mood' fair, brussels, september 2013, 10,000 attendees  
poster presentation, 'techtextil' trade fair, frankfurt june 2013, estimated 27,500 attendees  
workshop, student exchange event, ghent december 2013, 31 attendees  
leaflet distribution, euratex conference, brussels march 2014, 240 attendees  
scientific lecture by insa lyon, berlin august 2014, 600 attendees  
lecture, environord, lille june 2015, 70 attendees  
display stand, twi open day, cambridge october 2015, 90 attendees  
  
list of websites:  
http://www.texshield-project.eu/  
  
contact:  
steve kay ctext fti  
managing director  
north west textiles network limited  
suite 405, communications house, 514 blackburn road, bolton, bl1 8nw  
  
e: steve.kay@nwtexnet.co.uk   
w: www.nwtexnet.co.uk   
t: + 44 (0) 795 8338969

# TEX-SHIELD

Project Acronym: TEX-SHIELD

programme & topic: FP7-SME SME-2012-2

Most frequent returning words in objectives:

* ('project', 28)
* ('textile', 14)
* ('products', 14)
* ('materials', 14)
* ('performance', 12)
* ('water', 11)
* ('fluorine', 11)
* ('repellency', 10)
* ('pfcs', 10)
* ('tex-shield', 10)
* ('market', 10)
* ('pfoa', 9)
* ('textiles', 8)
* ('chemistry', 8)
* ('repellent', 8)
* ('pfos', 8)
* ('development', 8)
* ('work', 8)
* ('impact', 8)
* ('attendees', 8)
* ('coatings', 7)
* ('developed', 7)
* ('content', 7)
* ('industry', 7)

executive summary:  
for many years, numerous well-known brands of performance textiles have been coated with perfluorocarbon chemistry to impart highly durable oil and water repellent (dwr) properties to the textile. in the early stages of the technology, repellency was provided by simple paraffin or wax coatings, which washed out over time. following on from this, perfluorooctane sulfonate (pfos) and perfluorooctanoic acid (pfoa) are chemicals belonging to the family of perfluorochemicals (pfcs) and were developed into products which became known as 'c8 chemistry'. although pfc-c8 are used together with binders that act as glue to stick to the surface of fabrics, these are not chemically bonded to the substrate and can therefore leach out, potentially causing an environmental and/or ecological threat. in response to this, in january 2006, the u.s. environmental protection agency (epa) approached the eight largest fluorocarbon producers and requested their participation in the 2010/15 pfoa stewardship program, and their commitment to reduce pfoa and related chemicals globally in both facility emissions and product content by 95 percent by 2010, and 100 percent by 2015. additionally, pfos was added to annex b of the stockholm convention on persistent organic pollutants in may 2009. in response to these measures, the industry has developed perfluorohexanoic acid (pfha), also known as âc6 chemistryâ. although claimed to be less harmful than pfos, it is also less attractive to the end user both in effectiveness (i.e. how well the finished article repels water and/or oil) and durability ( i.e. how long the repellent effect lasts after wearing and washing).  
  
this leaves the textile and clothing supply chain, and its end users, with a problem: how to maintain established levels of performance in so-called dwr products whilst eliminating the undesirable c8 chemistry which is largely responsible for delivering the desired performance. the tex-shield project aimed to investigate potential solutions to this problem.   
  
during the early months of the project, the partners elected to investigate three categories of potential solution that would benefit not only the smes and sme-ags involved in the project, but also the wider textile and clothing supply chain. these categories were:  
1) âshorter chainâ pfc products with a view to identifying formulation and deposition parameters to yield optimum performance   
2) silicone/fluorosilicone approaches to reduce fluorine content whilst maintaining functional performance  
3) development of nano-structured fluorine free materials  
  
the full report for the tex-shield project contains an expanded discussion of the results of each of these approaches. although the ultimate goal of a pfc-free durable water repellent treatment for textiles is yet to be attained, the deeper understanding of the complexities of the subject obtained and the advances made during the tex-shield project has brought that day closer.  
  
project context and objectives:  
durable water and/or oil repellent treatments on textiles work by reducing the tendency of liquids to spread out and penetrate the fibres on contact with the substrate: instead, the liquid maintains a high âcontact angleâ with the substrate. the repellency finish allows liquids to bead up and roll off the fabric, or liquid spills to be easily wiped away with a clean cloth. thus, their usefulness in, for example, keeping skiers dry in heavy snowfall, or soft furnishings serviceable after food or drink spillages, is a highly desirable added-value attribute for the finished article.  
  
the current fluoropolymer-based stain repellent treatments are known to pose significant health concerns. pfcs are either produced by electrofluorination or teleromerisation, manufacturing processes which give out unintended by-products of perfluorooctane sulphonates (pfos) and perfluorooctanoic acid (pfoa). pfoa has the molecular formula c8f1502h while pfos is c8hf17o3s.  
  
during service life, the pfc treatment is gradually leached from the fabric, and decomposes to pfoa and pfos. both pfoa and pfos are very stable in the environment and, hence, are a significant ecological threat, as the levels reached in higher organisms (including people) can become significant. consequently, the u.s. environmental protection agency (epa) and some of the biggest fluoropolymer manufacturers have cooperated in studies and have collected and shared their findings. the following results have been highlighted from this research about pfoa and pfos:  
â¢ they are very stable in the environment, so they do not readily degrade.  
â¢ once they enter the human body they are eliminated very slowly. this means that they remain in the body for relatively long periods of time: the half-life in humans is about 4.5 years.  
â¢ they cause adverse effects in laboratory animals that have been given high doses over a long period of time.  
  
to put the project into economic context, the european commission identified personal protective equipment (ppe) as a âlead marketâ (defined as a market which presents âa significant potential for global market leadership by european companies based on important scientific and technological developments achieved by european researchersâ) also, the annual sales value of the outerwear market in the eu was estimated to be over â¬10 billion in 2012 (source: european outdoor group âstate of tradeâ report http://tinyurl.com/jox6nfu ). of this figure, 42% was defined as âouterwear topâ and a further 12% as âouterwear bottomâ garments. it is likely that a substantial percentage of these sales are for dwr products, which reinforces the importance of finding a suitable alternative to c8 chemistry. there is also significant demand for water and oil repellent garments (particularly in the ppe trade, which had a worldwide wholesale value of us$9.92 billion in 2014) and in soft furnishings (especially in the hotel trade), both of which have historically relied heavily on c8 chemistry to impart desirable characteristics to the finished product.  
  
it can be readily seen that there is significant market demand for the dwr family of products, and the tex-shield partnership is well placed to exploit any new technology developed by the project, consisting as it does of end users (eva commerce and panaz), and sme-ags with outdoor wear, ppe and contract furnishings businesses amongst their membership.   
  
in addition to the global details given above, a survey of smes throughout europe was undertaken by the project team to provide guidance on the requirements placed on new repellent coatings from an industrial perspective. in summary, the respondents were clear that they required high performance repellency for water and oil, but, surprisingly, retention for 5-10 washes was seen as adequate, with little requirement for considerably higher durability.   
  
  
the key objectives of the project were to investigate means of:  
1) eliminating problems with c8 pfcsâ by-products associated with textile treatments.  
2) providing a cost-effective alternative treatment which allows textiles to be provided with durable anti-soiling/anti-staining characteristics.  
3) reducing the total fluorine content in the treatment by means of new sol-gel derived additives in the form of nanoparticles or inorganic-organic hybrid networks.  
4) demonstrating performance on a representative scale, with regards to key technical parameters including soil resistance, abrasion resistance, cleaning cycle resistance.  
5) creating additional advantageous functions such as anti-static and anti-microbial characteristics to improve stability against mechanical, chemical impacts.  
6) developing flexible and versatile solutions for a broad range of textile supports different in structure (woven, knitted) and basic fibres (natural, synthetic or mixtures).  
7) developing a solution with a low ecological footprint, based on reach-proof chemicals and taking into account safety and health issues.  
8) providing a full life cycle analysis (including washability cycle) and assessment of techno-economic benefits, via benchmarking against current products.  
9) providing the necessary technological transfer and training via sme associations to ensure awareness and take up throughout the ec.  
  
project results:  
our work gave us a unique understanding of candidate alternative methods to confer water and oil repellency to textile fabrics. this led us to conclude that, in the short to medium term at least, industry standard replacement of pfc-c8 chemistry is most likely to come from shorter chain pfcs â either pfc-c4 or, most probably, pfc-c6. whether these alternatives will be acceptable in terms of environmental legislation remains to be seen. the german chemistry business rudolf chemie claimed in an issue of the magazine textile insights (february 2009) that âc6 is closest chemically to c8, but it contains no pfoa. it breaks down in the environment.â  
investigations into fluorine-free approaches led us to believe that the required standards of oil and soil repellence cannot be attained via non-fluorinated chemistries: some fluorine is likely to be required to produce an acceptable performance. on this basis hybrid systems such as fluoro-silicones may well offer promise as âcomposite approachesâ, containing reduced fluorine content but offering high water repellence with good handle and durability.  
  
nanotechnology is another option: this appears to be a promising approach and the industry has developed innovative methods to deliver the required performance. however, the long-term effect of this technology on the environment is not clearly understood.  
  
the coatings that have been developed and evaluated through this programme were intended to replace the incumbent materials but designed in such a way that the environment would be more tolerant toward them. to achieve this three approaches were followed:  
  
1) fluorocarbons with carbon chains smaller than eight.  
2) a polysiloxane loaded with silica nanoparticles.  
3) a completely fluorine-free nano-silica functionalised to provide repellency whilst binding to textile fibre surfaces.  
  
of these, approach 1 can be considerd as being closest to market as it was exploring the use of commercially available materials, such as c6 pfc. however it was established during this project that these shorter chained pfcs do not give comparable performance to the c8 pfcs. this implies that either the applications will have to accept a reduction in properties or the coatings will have to be boosted in some manner. this approach does offer a reduction in the perfluorocarbon content on fabrics and garments and reduces the environmental impact. the approach of a direct replacement of c8 by c6 perfluorocarbons also would fit with existing processes currently used in the textile industry. this means that energy and waste expenditure would be similar to current systems but with a reduction in the environmental impact caused by the c8 fluorocarbons.   
  
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however, the repellency to oil (oleophobicity) was not as good as the incumbent c8 perfluorocarbons. during the course of the project, attempts were made to improve the oil repellency, but that required the development of a novel post treatment that required a high temperature process and was also fluorine based, although smaller than the c8 fluorocarbons. it should also be stated that despite the post treatment, the level of oleophobicity was not still not comparable to the c8 pfc materials and so would require further development work before commercial trials were possible.   
  
using surface energy and contact angle measurements on model materials, the third approach demonstrated that by using functionalised nano-silica it should be possible to obtain a coating that had superhydrophobic and oleophobic properties without any fluorine content this approach is still at the lower technology readiness levels and requires further product development before it could be considered for market evaluation.  
  
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impact on eu society  
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dissemination  
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â¢ posters  
â¢ workshops organized by the 4 sme associations  
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poster presentation, 'techtextil' trade fair, frankfurt june 2013, estimated 27,500 attendees  
workshop, student exchange event, ghent december 2013, 31 attendees  
leaflet distribution, euratex conference, brussels march 2014, 240 attendees  
scientific lecture by insa lyon, berlin august 2014, 600 attendees  
lecture, environord, lille june 2015, 70 attendees  
display stand, twi open day, cambridge october 2015, 90 attendees  
  
list of websites:  
http://www.texshield-project.eu/  
  
contact:  
steve kay ctext fti  
managing director  
north west textiles network limited  
suite 405, communications house, 514 blackburn road, bolton, bl1 8nw  
  
e: steve.kay@nwtexnet.co.uk   
w: www.nwtexnet.co.uk   
t: + 44 (0) 795 8338969

# Powerweave

Project Acronym: Powerweave

programme & topic: FP7-NMP NMP.2011.4.0-3

Most frequent returning words in objectives:

* ('energy', 25)
* ('storage', 23)
* ('fibre', 19)
* ('fabric', 18)
* ('fibres', 17)
* ('power', 15)
* ('solar', 10)
* ('supply', 9)
* ('generation', 8)
* ('project', 8)
* ('materials', 8)
* ('methods', 7)
* ('applications', 7)
* ('development', 6)
* ('textile', 6)
* ('powerweave', 5)
* ('developed', 5)
* ('work', 5)
* ('demonstration', 5)
* ('airship', 5)
* ('time', 5)
* ('textiles', 4)
* ('photovoltaic', 4)
* ('batteries', 4)

executive summary:  
powerweave - development of textiles for electrical energy generation and storage  
  
  
a project funded by the european union seventh framework programme, running from june 2012 to november 2015.  
  
the fabric power supply  
  
the worldâs first continuously processed pv fibres and energy storage fibres have been developed in the powerweave project. they can be woven into a fabric which would act as a standalone power supply. the fabric would harvest and store electrical energy from the sun within its fibrous matrix. it is an easily deformable, storable, lightweight and transportable power supply.  
  
project context and objectives:  
objectives  
  
this project aimed to develop a fabric to harvest and store electrical energy within its fibrous matrix, to fulfil a need for an easily deformable, storable and transportable power supply.  
  
this was through the development of photovoltaic fibres and energy storage fibres integrated with control electronics into a textile. this unique approach, moving on from the current state of the art using rigid cell or film based pv materials and rigid bulky batteries, allows development of large-area deformable products, including agricultural shading, automotive soft-tops, building facades, rollable shades, curtains and roofing, aerospace fabrics, and outdoor goods.  
  
the key challenges were:  
  
â¢ formulation of pv and energy storage materials to be applied as flexible thin coatings on monofilament fibres. sme materials suppliers ppc (polymer coatings) will work with universities, epfl (pv) and brunel (energy storage) who are leaders in these fields.  
  
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potential impact:  
final results and impact  
  
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- flexible and conformable â facilitating new applications.  
- bendable interconnects â the entire module can be folded and bent.  
- significant reduction in weight compared with 1st, 2nd & 3rd generation solar cells and batteries.  
- from rollable to foldable, reduced size / volume = reduced transport costs  
- no installation is necessary; fold out and plug in.   
  
the materials and improved performance developed in photovoltaic and electrical energy storage will also have implications well beyond textiles applications. there is potential for lower cost, more widely applicable solar energy generation. the developments from powerweave are appropriate for generation in low light levels and a wide range of wavelengths. the energy storage materials are also low cost, readily available and light weight, and derivatives may find applications in automotive or domestic power units.  
  
amongst others, the following markets are envisaged:  
- sun screens / shading for commercial greenhouses  
- off-grid applications (incl. 3rd world)  
- wearable technology  
- airships with greater distance capability  
  
list of websites:  
www.powerweave.eu

# Powerweave

Project Acronym: Powerweave

programme & topic: FP7-NMP NMP.2011.4.0-3

Most frequent returning words in objectives:

* ('energy', 25)
* ('storage', 23)
* ('fibre', 19)
* ('fabric', 18)
* ('fibres', 17)
* ('power', 15)
* ('solar', 10)
* ('supply', 9)
* ('generation', 8)
* ('project', 8)
* ('materials', 8)
* ('methods', 7)
* ('applications', 7)
* ('development', 6)
* ('textile', 6)
* ('powerweave', 5)
* ('developed', 5)
* ('work', 5)
* ('demonstration', 5)
* ('airship', 5)
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* ('textiles', 4)
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a project funded by the european union seventh framework programme, running from june 2012 to november 2015.  
  
the fabric power supply  
  
the worldâs first continuously processed pv fibres and energy storage fibres have been developed in the powerweave project. they can be woven into a fabric which would act as a standalone power supply. the fabric would harvest and store electrical energy from the sun within its fibrous matrix. it is an easily deformable, storable, lightweight and transportable power supply.  
  
project context and objectives:  
objectives  
  
this project aimed to develop a fabric to harvest and store electrical energy within its fibrous matrix, to fulfil a need for an easily deformable, storable and transportable power supply.  
  
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- wearable technology  
- airships with greater distance capability  
  
list of websites:  
www.powerweave.eu

# NO BUG

Project Acronym: NO BUG

programme & topic: FP7-NMP NMP-2008-4.0-9

Most frequent returning words in objectives:

* ('project', 8)
* ('release', 5)
* ('textiles', 4)
* ('novel', 3)
* ('file', 3)
* ('d8.5a', 3)
* ('mosquito', 2)
* ('problems', 2)
* ('repellents', 2)
* ('systems', 2)
* ('multilayer', 2)
* ('mosquitoes', 2)
* ('executive', 1)
* ('summary', 1)
* ('operates', 1)
* ('framework', 1)
* ('programme', 1)
* ('research', 1)
* ('development', 1)
* ('demonstration', 1)
* ('collaborative', 1)
* ('smes', 1)
* ('duration', 1)
* ('months', 1)

executive summary:  
the no bug project operates within the 7th framework programme of the ec for research, technological development and demonstration. the project is a collaborative project for smes. the duration of the project was 48 months.  
  
no bug: novel release system and bio-based utilities for mosquito repellent textiles and garments  
  
in several applications of professional textiles and clothes mosquito repellency is an important issue. two major problems arise: repellents currently in use are harmful, resistance to conventional repellents increases, and the lifetime of release systems is too short. solving these two problems are the main goals of the no bug project.  
novel biorepellents have been selected. they have been combined with four release systems (multilayer coating, textile bio-aggregates, masterbatches and micro-capsules). this allows to repel mosquitoes transmitting malaria or dengue. the novel release concepts are multilayer coatings and in-situ release of the active compounds. targeted prototypes are textiles for health workers and bed nets (mosquitoes).  
  
project context and objectives:  
see attached file d8.5a  
project results:  
see attached file d8.5a  
potential impact:  
see attached file d8.5a  
list of websites:  
no bug website  
http://www.no-bug.info/content/about  
  
coordinator of the project: prof. lieva van langenhove  
ghent university - department of textiles  
technologiepark 907  
b-9052 zwijnaarde, belgium  
lieva.vanlangenhove@ugent.be

# AT~SEA

Project Acronym: AT~SEA

programme & topic: FP7-NMP NMP.2011.4.0-3

Most frequent returning words in objectives:

* ('project', 45)
* ('textile', 33)
* ('at~sea', 30)
* ('cultivation', 27)
* ('seaweed', 24)
* ('development', 19)
* ('biomass', 17)
* ('work', 13)
* ('materials', 12)
* ('results', 12)
* ('phase', 12)
* ('textiles', 11)
* ('exploitation', 11)
* ('storage', 10)
* ('plan', 10)
* ('demo', 10)
* ('energy', 9)
* ('activities', 9)
* ('material', 8)
* ('and/or', 8)
* ('multilayer', 8)
* ('substrates', 8)
* ('substrate', 8)
* ('design', 8)

executive summary:  
project context and main objectives  
today the total worldwide energy consumption is ca. 480 exajoules (ej, 480 ã 1018 j), with ca. 90% derived from the combustion of fossil fuels. fossil fuels, i.e. coal, oil and natural gas, are limited in supply and will one day be depleted. as a result the quest for renewable energies, being energies generated from natural resources such as sunlight, wind, tides, etc., and from industrial or urban waste and biomass, started decades ago. biomass energy, being the oldest source of renewable energy, is generally acknowledged as one of the most promising. the technology is based on converting biomass material (plants and animal waste) into energy (i.e. heat, electricity and/or chemicals, like methane gas, butanol, etc.).  
the choice for macroalgae based aquatic biomass cultivation in at~sea is based on the following reasoning: 1) 70% of the earthâs surface is ocean, thus there is a huge potential for biomass growth, 2) macroalgae grow much faster than conventional crops on land, 3) by producing the biomass at sea we avoid the discussions about land food crops being used as fuel/energy source. this is the so-called food-energy nexus.  
at~sea is a 3-year european project within fp7 (nmp work programme). the project aims at the development of advanced technical textiles in order to demonstrate the technical and economic feasibility of open sea cultivation of macroalgae (seaweed). the project targets the development of novel textile materials for 3 different elements of the aquatic biomass cultivation farms:  
1. advanced 3d multilayer textile substrates for seaweed cultivation  
the target is to identify 3d multilayer textile substrates incorporating woven, nonwoven and/or 3d fabrics based on advanced fibrous and fibre-composite materials. in order to facilitate (selective) growth on the textile surface, the different layer materials will be modified, e.g. by incorporating nutrients, fertilizers and/or other functional ingredients that are slowly released in time, by mechanical, physical and/or chemical modification of the fibre surfaces, etc.  
2. advanced textile based cables and connections for positioning and anchoring of the 3d multilayer textile substrate  
this part foresees the development of advanced textile based materials for robust, durable and high tensile strength cables and connections to position the cultivation substrate at open sea. engineering design will be tested and adjusted to north sea offshore conditions.  
3. advanced coated textiles for flexible and light-weight floatation tubes, as well as for storage and transportation tanks   
this part focuses on the development of advanced coated textiles for purposes like storage and transportation of the harvested biomass (flexitanks), for storage tanks such as offshore seaweed hatcheries, and for cleaning and regeneration tanks for the 3d multilayer textile substrate.  
  
by reaching these goals, at~sea targets at the development of innovative offshore textile products. further, it wants to stimulate bio-energy production from seaweed by enabling open sea large scale cultivation and harvesting.   
  
main results achieved  
in july 2015 the at~sea project reached its end point. after a period of 40 month, including three full cultivation seasons, we have made up our final project overview. the original work plan has been executed according to plan and there have been hardly any deviations. from a technical point of view lots of knowledge was acquired based on numerous tests that were performed in the different work packages. the following summarises the main results as obtained during the second phase of the project, m19 â m40:  
  
o in wp1 focus was on the value chain analysis for proposed solutions resulting in a full economic evaluation of seaweed cultivation in europe. this work was the start of the development of an extensive business plan for the start-up company at~sea technologies.  
  
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o wp3 further optimized the seaweed/substrate interaction, seeding method, and cultivation design. this resulted in a dedicated seeding formulation and procedure for the demo phase.  
  
o the work in wp4 was mostly performed in the first project period. in this reporting period focus was on mooring analyses, rope performance testing and splice design and integrity testing. this finally resulted in the identification of the appropriate mooring system for the demo phase.  
  
o in wp5 the material of choice was identified for the development of seaweed storage bags and textile buoys. detailed analysis of test results yielded one preferred coated textile material. this material was used to develop several prototypes of seaweed storage bags and textile buoys. wp5 ended with clear recommendations on the construction of these coated textile based devices.  
  
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o within wp8 focus was on dissemination and exploitation activities. the consortium extensively disseminated the project results to a broad range of stakeholders and finalized the project in may 20015 with the final at~sea event in brussels. other dissemination activities included the development of the project website, the making of the at~sea project movie and numerous presentations all over europe. concerning exploitation and ipr, the team developed a clear exploitation strategy that finally resulted in the founding of start-up company at~sea technologies. furthermore the advanced textiles as developed within the at~sea project were protected by patents.  
  
o the work in wp9 project management and coordination went according to plan. all deliverables and milestones were met and published in ecas. from a financial point of view there were no problems. in the last phase of the project the financial status of the project was evaluated and the psc agreed to transfer some budgets from one partner to another. on september 11, 2015 the at~sea project consortium had its final review meeting with the european commission.   
   
project context and objectives:  
project context and main objectives  
today the total worldwide energy consumption is ca. 480 exajoules (ej, 480 ã 1018 j), with ca. 90% derived from the combustion of fossil fuels. fossil fuels, i.e. coal, oil and natural gas, are limited in supply and will one day be depleted. as a result the quest for renewable energies, being energies generated from natural resources such as sunlight, wind, tides, etc., and from industrial or urban waste and biomass, started decades ago.   
biomass energy, being the oldest source of renewable energy, is generally acknowledged as one of the most promising. the technology is based on converting biomass material (plants and animal waste) into energy (i.e. heat, electricity and/or chemicals, like methane gas, butanol, etc.).  
the choice for macroalgae based aquatic biomass cultivation in at~sea is based on the following reasoning: 1) 70% of the earthâs surface is ocean, thus there is a huge potential for biomass growth, 2) macroalgae grow much faster than conventional crops on land, 3) by producing the biomass at sea we avoid the discussions about land food crops being used as fuel/energy source. this is the so-called food-energy nexus.  
at~sea is a 3-year european project within fp7 (nmp work programme). the project aims at the development of advanced technical textiles in order to demonstrate the technical and economic feasibility of open sea cultivation of macroalgae (seaweed). the project targets the development of novel textile materials for 3 different elements of the aquatic biomass cultivation farms:  
1. advanced 3d multilayer textile substrates for seaweed cultivation  
the target is to identify 3d multilayer textile substrates incorporating woven, nonwoven and/or 3d fabrics based on advanced fibrous and fibre-composite materials. in order to facilitate (selective) growth on the textile surface, the different layer materials will be modified, e.g. by incorporating nutrients, fertilizers and/or other functional ingredients that are slowly released in time, by mechanical, physical and/or chemical modification of the fibre surfaces, etc.  
2. advanced textile based cables and connections for positioning and anchoring of the 3d multilayer textile substrate  
this part foresees the development of advanced textile based materials for robust, durable and high tensile strength cables and connections to position the cultivation substrate at open sea. engineering design will be tested and adjusted to north sea offshore conditions.  
3. advanced coated textiles for flexible and light-weight floatation tubes, as well as for storage and transportation tanks   
this part focuses on the development of advanced coated textiles for purposes like storage and transportation of the harvested biomass (flexitanks), for storage tanks such as offshore seaweed hatcheries, and for cleaning and regeneration tanks for the 3d multilayer textile substrate.  
  
by reaching these goals, at~sea targets at the development of innovative offshore textile products. further, it wants to stimulate bio-energy production from seaweed by enabling open sea large scale cultivation and harvesting.   
  
project results:  
this part has been extensively described in the final progress report (confidential). underneath the main results have been summarized.  
  
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potential impact:  
these topics have been extensively described in the final status report that was published in september 2015. the text underneath summarizes this part.  
  
exploitation  
although being a research project that targeted the development of advanced textiles for open sea biomass cultivation, the at~sea project went much further than this. during the course of the project the consortium clearly saw the economic potential of seaweed cultivation in europe and developed an exploitation team. this exploitation team developed a detailed business plan for the global exploitation of seaweed farms and presented this plan to the consortium. this finally resulted in the founding of the spin-off company at~sea technologies (ast). ast will further optimize the foreground that was developed during the at~sea project. during the cultivation season 2015/2016 it will deploy a 1 ha seaweed farm in norway. in the season 2016/2017 this field will be enlarged to 4 ha. by mid 2017 all engineering activities shall result in a first generation seaweed farm that will be available for customers. during the first year ast will be managed by former consortium members; in the second year ast will hire its first employees.  
other points worth mentioning here:  
â¢ a fruitful exploitation strategy seminar was organized during the m24 general assembly in porto.  
â¢ sioen and centexbel submitted a belgian patent application for the results obtained on the use of textile substrates (wp2 work); together with horti they also filed a pto patent application in this area  
  
dissemination  
the key activities concerning dissemination activities are:  
â¢ the at~sea web site was kept up to date by adding frequently news item, e.g. related to the progress of the seaweed growth at the partners.   
â¢ it was ensured that the at~sea project was presented at some key events, that covered a broad stakeholder audience (seaweed sector, aquaculture sector, energy sector, etc.).  
â¢ in september 2014 a workshop took place with ngoâs discussing the environmental impact of large scale seaweed cultivation in europe.  
â¢ in june 2015 the final at~sea event took place showcasing all aspects of the at~sea project to a wide stakeholder audience.  
â¢ partners sioen and centexbel received the techtextil 2015 innovation award for their research towards seaweed cultivation substrates. furthermore the at~sea project received several award nominations.  
  
list of websites:  
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