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d'Estudis  
Catalans



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**Anna Mujal** (Universitat Politècnica de Catalunya, UPC)

**Neus Vidal** (Universitat de Barcelona, UB)

## PROGRAMA

### BENVINGUDA (9:15 -9:30):

Arantxa Fraile Rodríguez i Sònia Estradé (AMIT-Cat) i Alícia Casals (IEC)

### SESSIÓ 1 (9:30 – 11:45)

*Chairs: Anna Laromaine (ICMAB-CSIC) i Azucena Bardají (ISGlobal)*

- **Nora Ventosa (Invitada)**, Desenvolupament de nanomedicines: recerca bàsica i col·laboració amb l'empresa, Institut de Ciència de Materials de Barcelona, ICMAB-CSIC. Bellaterra.
- Ariadna Boloix, Quatsomes are a novel platform to deliver RNA-based therapies for càncer, Vall d'Hebron Research Institute (VHIR), Barcelona.
- Amanda Muñoz-Juan, C. elegans model, a valuable step in the bio-evaluation of nanomaterials, Institut de Ciència de Materials de Barcelona, ICMAB-CSIC. Bellaterra.
- Coral García Fernández, Stealth polyplexes to control the biological fate of nanomedicines, Institut Químic de Sarrià, Universitat Ramón Llull, Barcelona.
- Anna Lagunas, Deciphering membrane protein function at the nanoscale, Institute for Bioengineering of Catalonia (IBEC), Barcelona.
- **Mónica García-Mota (Invitada)**, Atomistic Simulation Advanced Platform (ASAP) for materials modelling with ab initio methods, SIMUNE Atomistics, Donostia.
- Negar Ahmadi, Transdermal permeation of an arylalkanoic acid non-steroidal anti-inflammatory drug carried in a pluronic® F127 hydrogel loaded with lipid nanocarriers for the treatment of local inflammation, Facultat de Farmàcia i Ciències de l'Alimentació, Universitat de Barcelona, Barcelona.
- Ramona Santini, Drug loading strategies for discotic amphiphile supramolecular polymers in wàter, Institute for Bioengineering of Catalonia (IBEC), Barcelona.
- Galyna Maleeva, Donor-acceptor Stenhouse adduct-based photooswitch for GABA receptors, Institute for Bioengineering of Catalonia (IBEC), Barcelona.
- Paola Bustos-Salgado, Skin permeation study of derivative flavanone carried in a PLGA Nanoparticle System, Facultat de Farmàcia i Ciències de l'Alimentació, Universitat de Barcelona, Barcelona.
- Negar Beirampour, Baricitinib in Poly(epsilon-caprolactone) nanoparticles for ocular drug delivery, Facultat de Farmàcia i Ciències de l'Alimentació, Universitat de Barcelona, Barcelona.

### PAUSA CAFÈ (11:45-12:15)

## **SESSIÓ 2 (12:15 – 13:45)**

*Chairs: Marta González (UAB i ICN2) i Arantxa Fraile Rodríguez (IN2UB)*

- **Marta Estrader** (*Invitada*), Unveiling new insights into bi-magnetic antiferromagnetic/ferrimagnetic Core/Shell nanoparticles: a multicharacterization approach, Dept. Química Inorgànica i Orgànica, Universitat de Barcelona, Barcelona
- Karen Mejía-Carmona, Cerium - doped Magnetite Nanoparticles: Synthesis and Characterization, Catalan Institute of Nanoscience and Nanotechnology (ICN2), CSIC and BIST, Bellaterra.
- Marta Xiulan-Aribó, Probing single antiferromagnetic NiO nanoparticles by synchrotron-based X-ray spectromicroscopy, Departament Física de la Matèria Condensada, Universitat de Barcelona, Barcelona.
- Ana M. López-Periago, Nanoporous composites prepared using supercritical fluids, Institut de Ciència de Materials de Barcelona (ICMAB-CSIC), Bellaterra.
- Marta Rodríguez-López, Electric fields for tuning molecular orientation in TPD-modified glasses: experiments and simulations, Group of Thermal properties of Nanoscale Materials, Universitat Autònoma de Barcelona, Bellaterra.
- Marta Ruiz-Ruiz, Glass transition in ultrastable glasses: a close look by means of AFM, Depto. Física, Universitat Autònoma de Barcelona, Bellaterra.
- Rosario Núñez, Exploring Icosahedral Boron Clusters in Nanomaterials, Institut de Ciència de Materials de Barcelona (ICMAB-CSIC), Bellaterra.
- Núria Aliaga-Alcalde, Use of curcuminoids in molecular electronics and as sensors, ICREA i Institut de Ciència de Materials de Barcelona (ICMAB-CSIC), Bellaterra.

## **PAUSA DINAR (13:45 – 15:30)**

## **SESSIÓ 3 (15:30 – 17:40)**

*Chairs: Francesca Campabadal (IMB-CNM, CSIC) i Arancha González (ICMAB, CSIC)*

- **Adriana I. Figueroa** (*Invitada*), Spintronics in novel quantum materials: interfacial phenomena, Dept. Física de la Matèria Condensada, Universitat de Barcelona, Barcelona.
- Regina Galceran, 2-dimensional materials at the interfaces of spintronic devices, Dept. Física Aplicada, Universitat de Barcelona, Barcelona.
- Elif Oceri, Advanced Processing of Epitaxial Graphene grown on SiC for the Fabrication of Top-Gated Graphene FETs, Institut de Microelectrònica de Barcelona (IMB-CNM, CSIC), Bellaterra.
- Susagna Ricart, Tunable BaMO<sub>3</sub> (M= Ti, Zr and Hf) Nps used on CSD approach to YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-δ</sub> superconducting layers, Institut de Ciència de Materials de Barcelona (ICMAB-CSIC), Bellaterra.
- Beatriz Vargas, TEM analysis for Thin-Film Ferroelectric Orthorhombic  $\alpha$ -Pr<sub>2</sub>WO<sub>6</sub> Polymorph, Dept. Electronics and Biomedical Engineering, Universitat de Barcelona, Barcelona.

- Mercedes Saludes-Tapia, Caracterización, modelización y simulación de memristores basados en estructuras MIM, Institut de Microelectrònica de Barcelona (IMB-CNM, CSIC), Bellaterra.
- Annalisa Calò, Spatial mapping of cells and tissues properties at small scales by AFM, Facultat de Física, Universitat de Barcelona, Barcelona.
- Sílvia Pujals, Super resolution microscopy applied to nanomedicine, Institute for Advanced Chemistry of Catalonia (IQAC), CSIC, Barcelona.
- Maria Guix, 3D printing technologies for the development of living robòtics, Dept. Ciència dels Materials i Química Física, Institut de Química Teòrica i Computacional, Universitat de Barcelona, Barcelona.
- **Sílvia Simón (Invitada)**, Institut de Química Computacional i Catàlisi, Universitat de Girona, Girona.
- Ana B. Caballero, La vuelta al cole de una nanoexperta, Dept. Química Inorgànica I Orgànica, Facultat de Química, Universitat de Barcelona, Barcelona.

#### **PAUSA CAFÈ (17:40 – 18:10)**

#### **TAULA RODONA (18:10)**

*Divulgació i comunicació de la nanociència.*

*Participants: Sílvia Simón, Montse García del Muro, Carmen Ocal i Susagna Ricart.*

*Modera: Ana B. Caballero.*

## Quatsomes are a novel platform to deliver RNA-based therapies for cancer

**Arianda Boloix<sup>1</sup>, Mariana Köber<sup>2,3</sup>, Adrià Molero-Valenzuela<sup>1</sup>, Josep Merlo<sup>4</sup>, María José Pérez-García<sup>1</sup>, Laia Avilés-Domínguez<sup>2</sup>, Júlia Piqué-Ponti<sup>2</sup>, Aroa Soriano<sup>1</sup>, Josep Roma<sup>1</sup>, Alba Córdoba<sup>4</sup>, Santi Sala<sup>4</sup>, Lucas Moreno<sup>1</sup>, Nora Ventosa<sup>2</sup>, Miguel F Segura<sup>1</sup>.**

<sup>1</sup>*Group of Childhood Cancer and Blood Disorders. Vall d'Hebron Research Institute (VHIR), Barcelona, Spain.*

<sup>2</sup>*Institut de Ciència de Materials de Barcelona (ICMAB-CSIC), Esfera UAB, Cerdanyola del Vallès, Spain.*

<sup>3</sup>*CIBER de Bioingeniería, Biomateriales y Nanomedicina (CIBER-BBN), Madrid, Spain.*

<sup>4</sup>*Nanomol Technologies SA, Mòdul de Recerca B, Campus Universitari de Bellaterra, Cerdanyola del Vallès, Spain.*

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RNA-based therapies against cancer could expand significantly the number of potential therapeutic targets, since they should be able to target all the transcriptome. One of the most therapeutically-advanced RNA molecules are microRNA (miRNA) and small interfering RNA (siRNA). However, *in vivo* administration has some challenges such as stability, rapid clearance or inappropriate biodistribution. Hence, conjugation of RNAs to nanoparticles could be a good strategy for improving the efficacy and selectivity to cancer cells. Lipid-based nanovesicles have been widely used for nucleic acids delivery and one of them, liposomes, were the first that reach the market<sup>1</sup>. Nevertheless, there is not a standard formulation for their clinical administration, due to limited manufacturing possibilities at industrial level<sup>2,3</sup>.

Our aim is to develop a clinical nanomedicine based on a different class of non-liposomal lipid-based vesicles named Quatsomes, which can be conjugated with tumor suppressor small RNAs for cancer treatment.

Quatsomes are generated by the spontaneous self-assembly of quaternary ammonium surfactants and sterols using a compressed fluid-based technology, called DELOS-SUSP. Compared to liposomes, QS show high homogeneity, long-term stability, high complexation and transfection efficiency of small RNAs<sup>4,5,6</sup>. Moreover, QS preparation by DELOS-SUSP is a green and scalable procedure. In addition, we demonstrate that QS-sRNA complexes can exert tumour-suppressive effects using small RNAs (i.e. miR-323a-5p and siKIF11) by halting cell proliferation in preclinical models of high-risk neuroblastoma (NB), an aggressive paediatric tumour that requires new treatments. Our results showed that QS-miRNA complexes administered intratumorally can reach cancer cells and release their cargo, triggering the expected anti-tumoral molecular response. Moreover, systemic administration of QS-miRNA complexes can also reach other organs that are frequently colonized by metastatic NB such as liver or lungs.

In summary, our nanomedicine, composed by tumour-suppressive sRNAs and QS nanocarrier, could be a potential treatment for tumors such as high-risk neuroblastoma.

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## ***C. elegans* model, a valuable step in the bio-evaluation of nanomaterials**

**Amanda Muñoz-Juan<sup>a</sup>**, S.Sumithra Yasaswini<sup>a</sup> and Anna Laromaine<sup>a</sup>

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In nanomedicine, a small percentage of nanomaterials reached the market[1] due to unexpected effects observed in clinical trials. To save time and money, models[1] between the in vitro and in vivo evaluation are used to get helpful information and optimize candidates before starting clinical trials. Among them, the 1 mm-long nematode *Caenorhabditis elegans* (*C. elegans*) has been widely used as an assessment platform of nanomaterials[2,3] due to its transparency, short life cycle, a large number of progeny and high genetic homology with humans. Moreover, it can be easily maintained in the laboratory in agar plates, providing a tool to quickly test new nanomaterials' modifications.

Following this strategy, we have evaluated different nanomaterials[3,4]. In this work, we studied the impact of supplementing a diet with bacterial nanocellulose fibers (BNCf). The results show that BNCf are not toxic for *C. elegans* but produces some alterations in their lipid metabolism and genetic expression, indicating a potential use of BNCf as a dietary fiber.

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## Stealth polyplexes to control the biological fate of nanomedicines

**Coral García Fernández<sup>a</sup>**, Santiago Fernández González<sup>b</sup>, Cristina Fornaguera Puigvert<sup>a</sup>, Salvador Borrós Goméz<sup>a</sup>

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<sup>b</sup> *Group of Infection and Immunity, Institute for Research in Biomedicine, Bellinzona, Switzerland*

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mRNA-based vaccines symbolize a new paradigm shift in personalized medicine for the prophylaxis and treatment of infectious and cancer diseases [1]. The current interest is further powered by the success of mRNA-based vaccines to combat the COVID-19 pandemic. Despite their probed potential, hurdles for their transfer to therapeutic applications *in vivo*, and thus, their implementation into a suitable technology, remain. These drawbacks are mainly related to the lability of mRNA, evidencing the importance of suitable carriers to deliver the genetic material. However, the fast clearance of mRNA delivery vehicles and the current platforms' lack of specificity to Antigen-Presenting Cell (APC) populations hinders the efficacy of these formulations [2,3]. The former causes a positive inflammation that induces the recruitment of immune cells; however, an excessive response ultimately leads to organ failure [4]. The latter is explained by low-circulation time of delivery carriers and complement activation. Thus, the development of non-immunogenic, easily tunable alternative materials for mRNA delivery that target specific organelles is pivotal to implementing mRNA-based therapies.

This work aims to describe our new proprietary polymer-based mRNA delivery vectors. These vehicles allows to properly control the interaction of the system with the proteins of the physiological media, ensuring an specific delivery of the cargo. The results obtained in the prophylactic and therapeutic vaccination in murine models, will serve as basis for the development of a novel type of mRNA delivery vehicles for further application in immunotherapies.

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## Deciphering membrane protein function at the nanoscale

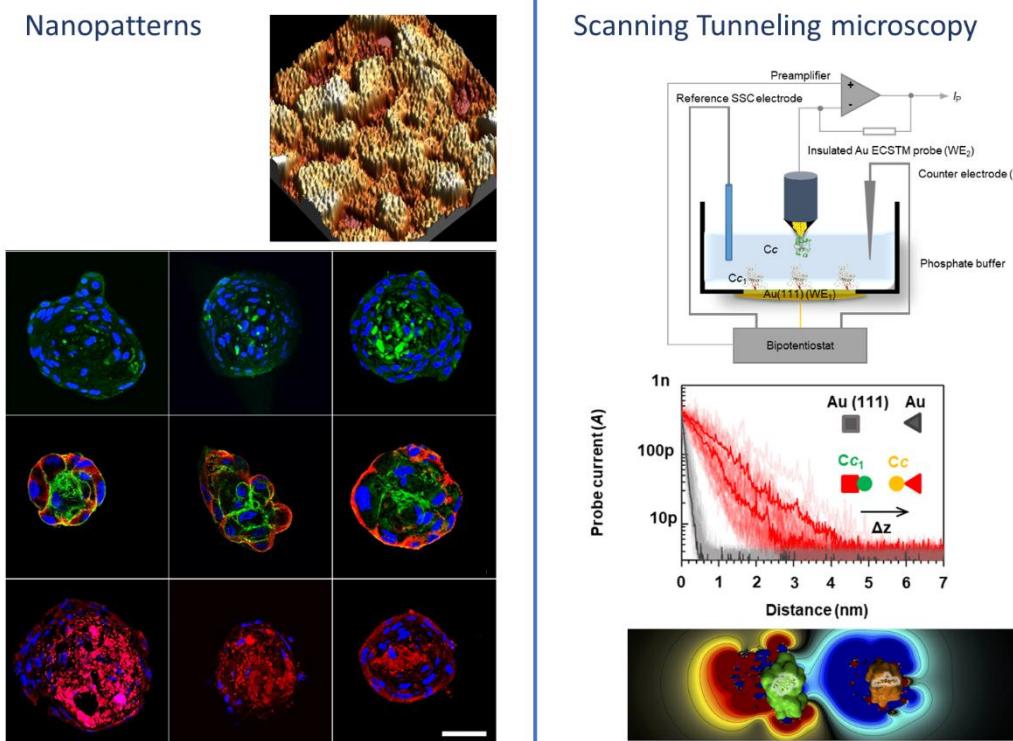
**Anna Lagunas<sup>a,b</sup>**

<sup>a</sup> CIBER-BBN, ISCIII, Barcelona, Spain.

<sup>b</sup> Institute for Bioengineering of Catalonia (IBEC), The Barcelona Institute for Science and Technology (BIST), Barcelona, Spain

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Currently Senior Researcher at the Nanobioengineering group of IBEC led by Prof. Josep Samitier, where I am coordinating the research line of Nanotechnology applied to biomolecule interaction studies and micro/nano-environments for regenerative medicine applications. My research interests focus on deciphering protein function and cell response at the nanoscale, thus revealing traits which are normally hidden by the ensemble average in bulk experiments. The interrogation of cells at the single-molecule level by developing nanostructured materials and using high resolution microscopy techniques provide an otherwise unavailable insight on the complex mechanisms regulating cell behaviour. In this talk, I will review my work dealing with the fabrication of nanopatterned substrates that promote membrane's receptor nanoclustering and cell signaling in adhesion, differentiation and intercellular communication processes, mainly applied to the regeneration of the musculoskeletal system [1-6]. I will also discuss the application of electrochemical scanning tunnelling microscopy (EC-STM) to study the electrical properties of membrane-bound proteins and our recent findings obtained by using this technique [7-9].



**Figure.** Left: dendrimer-based nanopatterns as seen by atomic force microscopy imaging (2.5x2.5  $\mu\text{m}$ ). Nanopatterns with different cell adhesiveness can be obtained. Below, representative confocal projections of mesenchymal stem cells cultured on the nanopatterns under chondrogenic

induction forming cell condensates. Decreasing nanopattern adhesiveness to the right. Cell nuclei in blue. Matrix protein collagen (COL2A1) in green in the first row, focal adhesion adaptor protein paxillin in red and actin cortex in green in the second row, and gap junction protein connexin (Cx43) in red in the third row. Scale = 20  $\mu$ m. On the right: electrochemical scanning tunneling microscopy (EC-STM) set-up for the study of the electron transfer (ET) between cytochrome *c* (*Cc*) and one of its molecular partners in the mitochondrial respiratory chain, cytochrome *c*<sub>1</sub> (*Cc*<sub>1</sub>). Long-range ET was observed in solution, which was attributed to the formation of a charge conduit between the two proteins.

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INVITED

**Atomistic Simulation Advanced Platform (ASAP) for materials modelling  
with ab initio methods**

Federico Marchesin<sup>a</sup>, Peter Koval<sup>a</sup>, Yann Pouillon<sup>a</sup>, Irina Lebedeva<sup>a</sup>, Asier García<sup>a</sup>, Anna Kimmel<sup>a</sup> and Mónica García-Mota<sup>a</sup>

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ASAP is a powerful platform for materials design [1], devoted to construction, steering and analysis of atomistic calculations. The platform facilitates the design of complex structures thanks to its powerful structure builder. Several automated workflows are designed for modeling and analysis of challenging systems. ASAP is linked to the SIESTA code [2], known for its exceptional performance for computationally demanding systems ( $>10^4$  atoms). The ASAP platform brings effective analysis tools for structure, chemical, electronic and dynamic properties relevant for modeling a wide range of systems semiconductors to biological systems.

#### References

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## Transdermal permeation of an arylalkanoic acid non-steroidal anti-inflammatory drug carried in a pluronic® F127 hydrogel loaded with lipid nanocarriers for the treatment of local inflammation

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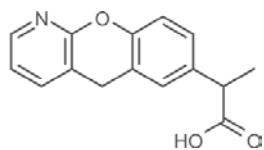
Pranoprofen (PF), (Figure 1a) is a non-steroidal anti-inflammatory drug (NSAID). Despite the high anti-inflammatory and analgesic potency, the oral administration of PF is somehow limited because of its inadequate biopharmaceutical profile. Nanostructured Lipid Carriers (NLC) are one of the colloidal systems that have been most widely studied over the past few decades with the aim of improving the penetration and delivery of drugs in the skin. In chronic lesional skin affected by inflammatory disorders, the differentiation process of the keratinocytes, the biosynthesis of the stratum corneum and its lipid composition and organization are altered. Lipid nanoparticles loaded in Pluronic gels (Figure 1b) are a novel method for the treatment of local skin inflammatory diseases.

**Objective:** The evaluation of pluronic hydrogel bearing pranoprofen loaded nanostructured lipid as a means of exploring novel formulations to investigate the skin permeation profile of this drug for the treatment of skin inflammatory disorders, and the physicochemical characterization and the study of the extensibility of the formula developed.

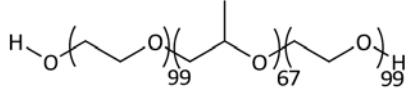
**Methods:** The nanostructured lipid carriers were obtained by a high-pressure homogenization method. For the hydrogel preparation, Pluronic® F127 was slowly added to previously cooled Milli-Q water until a final concentration of 18% of Pluronic® F127. This mix was kept under magnetic stirring at a constant speed until the complete solubilization of the polymer. The Pluronic® F127 hydrogel was kept refrigerated for 24 h. Finally the NLCs was added to the hydrogel under magnetic stirring until complete homogenization had been achieved and a final formulation of 10.7 mg PF/g gel was obtained in order to keep an effective drug concentration, and the particle size was determined. *Ex vivo* skin permeation studies were performed with amber vertical glass Franz diffusion cells, the hydrogel was added in the donor compartment in direct contact with dermatomed human skin with a diffusion area of 0.64 cm<sup>2</sup>, PBS (pH 7.4) was used as a receptor medium. Samples were withdrawn at different time points for 36 h and drug quantified by a validated HPLC method. The skin was cleaned using a 0.05% solution of sodium laurylsulphate and it was washed in distilled water. The drug skin extraction was treated with a mixture of methanol: water (50:50) under sonication using an ultrasound bath.

For extensibility (spreadability) assay an amount of hydrogel was placed within a 10 cm diameter circle pre-marked on a glass plate, over which another glass plate was placed, as centred as much as was possible. Increasing standard weight pieces (5, 10, 15, 25, and 50 g) were added by resting them on the upper glass plate for 60 s. The increase in the diameter, due to the hydrogel spreading, was noted. The formulation was analysed in accordance with the best kinetic model (n=3).

**Results:** The developed PF-NLCs exhibits a mean particle size of around 248.40 nm and presented 83.33 µg/g/cm<sup>2</sup> of retained amounts after 36 h in the skin, and 1.13 µg/h/cm<sup>2</sup> of median flux. According to the mathematical modelling, the formulation showed a first order (one-phase exponential association) kinetic profile.



(a)



(b)

**Figure 1.** (a) Pranoprofen chemistry structure; (b) Pluronic F127® chemistry structure.

## References

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## DRUG LOADING STRATEGIES FOR DISCOTIC AMPHIPHILE SUPRAMOLECULAR POLYMERS IN WATER

Ramona Santini<sup>a,b</sup>, Edgar Fuentes<sup>a</sup>, Galyna Malieieva<sup>a</sup>, Carlo Matera<sup>a,c,d</sup>, Fabio Riefolo<sup>a</sup>, Lorenzo Albertazzia<sup>a,e</sup>, Pau Gorostiza<sup>a,d,f</sup>, Silvia Pujals<sup>a,g</sup>.

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BTA-based supramolecular polymers are interesting systems for medical applications because of their high dynamicity and stimuli responsiveness in water<sup>1</sup>. Recently, IBEC developed a new class of BTA-based supramolecular polymers which showed responsiveness to temperature, salt concentration, pH, and light<sup>2</sup>. This versatility makes this new class of self-assembled fibers appealing for drug delivery purposes. In this work, we explored two strategies to incorporate different biologically active ligands into these polymers and demonstrate their employability as **light-driven drug delivery systems**. In the first strategy, we used a **co-assembly** approach in which two new discotic BTA-azo-monomers assemble forming the final helicoidal supramolecular fibers. In the second one, we decided to cage Photoiperoxo<sup>3</sup>, a potent photoswitchable derivative of the mAChR agonist Iperoxo<sup>3</sup>. Here, the interaction is based on the **stacking** between the azobenzene units of the ligand and the monomers. From the first approach, we obtained satisfying co-assembly results which were evaluated by transmission electron microscopy. Remarkably, the second system showed light-dependent biological effects in calcium imaging experiments on cells overexpressing M1 mAChRs. While caged Photoiperoxo did not evoke significant changes, UV pre-illuminated fibers caused an increase in intracellular calcium levels because of the activation of M1 mAChRs by the uncaged ligand. These results suggest that the new class of BTA-based supramolecular polymers<sup>2</sup> can potentially be used as light-driven drug delivery system for small, planar and amphiphilic drugs.

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## Donor-acceptor Stenhouse adduct-based photooswitch for GABA receptors

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Photopharmacology is a rapidly evolving field of the life science, at the crossroads of modern pharmacology, photochemistry, biology, and personalized medicine. Photopharmacology is based on the ability of photochromic organic molecules to undergo a conformational change upon light exposure, consequently causing modifications in their chemical and physical properties. Photopharmacological approach was successfully employed for the light-driven control of various biological processes, especially in the nervous system. Recently we have developed a first photoswitchable channel blocker of GABA receptors, first photoswitchable fulgimide-based potentiator of GABA<sub>A</sub>Rs and first photoswitchable modulator of glycine receptors. Here, we demonstrate a new model compound – DASA-barbital, based on a scaffold of red-switching second-generation DASAs.

Following the synthesis procedure, we have shown that DASA scaffold is amenable to rationally design red-switching barbiturate ligands. The UV-vis absorption spectrum of DASA-barbital in DMSO has shown a narrow absorption band around 615 nm that is consistent with the bright blue colour of the solution and makes it a molecule with unique photoswitching properties. DASA-barbital can be reversibly photoswitched in water using a pharmaceutical excipient. Biological activity of DASA-barbital was studied at cultured hippocampal neurons using current clamp and voltage clamp modes of patch-clamp technique. We have demonstrated that DASA-barbital can regulate the amplitude of spontaneous inhibitory postsynaptic currents and frequency of neuronal firing.

Our results show that DASA-barbital is active in neurons via GABA<sub>A</sub>Rs, which raises exciting prospects for photopharmacology and neurobiology. Receptor binding is retained in the cyclic form despite its bulky structure and the absence of branching, which contrasts with most barbiturates. DASA-based neuroactive molecules are widely appealing because they can be photoswitched with red and near infra-red light.

## Skin permeation study of derivative flavanone carried in a PLGA Nanoparticle system

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Plants have been the basis of many medicinal systems throughout the world for thousands of years and, continue to provide new therapeutic resources. Recently, derivatives flavanones obtained by different reactions from natural flavanone extracted from *Eysenhardtia platycarpa* have demonstrated their antiinflammatory effect *in vitro* and *in vivo* models in solution and carried in nanoemulsions [1, 2]. Polymeric nanoparticles are another nanoscale drug delivery systems that provide advantages like allowing active compounds to reach the site of action at therapeutic concentrations and to remain for a longer time to achieve their effect [3].

**Objective:** To investigate the skin permeation profile of a PLGA nanoparticle of a derivative flavanone ((2S)-5-hydroxy-7-methoxy-6-(3-methyl-2-buten-1-yl)-2-phenyl-2,3-dihydro-4H-1-Benzopyran-4-one) (1') intended for topical administration. **Methods:** The derivative flavanone 1' was obtained by methylation reaction from natural flavanone (2S)-5,7-dihydroxy-6-(3-methyl-2-buten-1-yl)-2-phenyl-2,3-dihydro-4H-1-Benzopyran-4-one (1) (Figure 1). The polymeric nanoparticles flavanone 1' (NP1') were prepared with PLGA and P188 as a surfactant by solvent displacement technique. The particle size was determined and *ex vivo* permeation studies were performed with vertical Franz diffusion cells with dermatomed human skin ( $n = 3$ ). Samples were withdrawn at different time points for 24 h and quantified by a validated HPLC method. The flavanone skin extraction was conducted by sonication with a mixture of Ethanol: water (70:30).

**Results:** NP1' with  $141.63 \pm 0.78$  nm of Z-average of size presented 17.8  $\mu\text{g}$  and 10.3  $\mu\text{g}/\text{cm}^2$  of permeated and retained amounts of 1' after 24 h in the skin respectively and, 0.03  $\mu\text{g}/\text{h cm}^2$  of average flux.

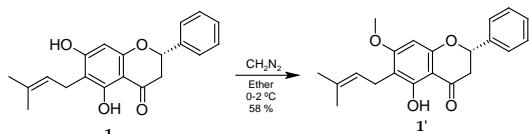


Figure 1. Methylation reaction of 1 to produce 1'.

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## Baricitinib in Poly(epsilon-caprolactone) nanoparticles for ocular drug delivery

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**Introduction:** The development of appropriate delivery systems that can sustain and deliver therapeutics to the target tissues is a key challenge that can be addressed by nano-technology [1]. Nanoparticles are being used in a variety of ophthalmological applications and can be fabricated with various simple techniques, such as solvent evaporation, emulsification encapsulation, ionotropic gelation, surface conjugation, which require less purification procedures, leading to high encapsulation efficacy, drug loading, and improved scale-up[2]. Poly caprolactone (PCL) is degraded by hydrolysis of its ester linkages in physiological conditions such as in the human body; and has, therefore received a great deal of attention for use as an implantable biomaterial. In this study, we proposed PCL-based NPs loading baricitinib (BNB) as an effective ocular drug delivery system to reduce irritation. BNB is a small molecule, a Janus Kinase inhibitor with selectivity for JAK2 and JAK1. This inhibition may reduce inflammation, cellular activation, and proliferation of key immune cells.[4]

**Objective:** The main objective of the present study is to improve the corneal penetration of BNB by means of PCL-based NPs and evaluate their anti-irritation effect.

**Methods:** NPs were prepared by a single emulsion and evaporation method. Briefly, 10 mg of BNB and 50 mg of PCL were dissolved in 10 mL of acetone in an ultrasonic water bath; this solution was then added dropwise to a 50 mL solution of 0.4% poloxamer 188 (P188) under a magnetic stirrer. Then, the organic solvent was allowed to evaporate overnight under continuous stirring. Their size was determined by photon correlations spectroscopy (PCS) with a Zetasizer Nano ZS, providing in parallel the width of the size distribution expressed as polydispersity index (PDI). Permeation studies were performed with pig' eyes using vertical amber glass Franz-type diffusion cells. Finally, the tolerance of the formulations on the ocular tissues was evaluated by the hen's egg-chorioallantoic membrane test (HET-CAM).

**Results:** NPs show with suitable physicochemical properties for ocular administration. The average size and PDI of PCL were obtained in the range of  $138.36 \pm 0.92$ ,  $0.92 \pm 0.022$  nm Baricitinib permeated through porcine cornea suggesting that the PCL NPs could lead to a topical effect, yet, no systemic effect would be expected since the steady state predicted plasma concentration ( $C_{ss}$ ) was below the therapeutic concentrations in plasma. Moreover, the formulations showed no irritant effects on the chorioallantoic membrane.

**Conclusion:** These data demonstrate that PCL NPs are promising vehicles for ocular drug delivery.

**Keywords:** janus kinase inhibitor; ocular delivery; ocular tolerance; transcorneal permeation; Nanoparticles

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# Unveiling new insights into bi-magnetic antiferromagnetic/ferrimagnetic Core/Shell nanoparticles: a multicharacterization approach

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FeO/Fe<sub>3</sub>O<sub>4</sub> core/shell nanoparticles are a subject of considerable current interest both due to their appealing magnetic properties (e.g., tunable exchange bias or the presence of both a Néel and a Verwey transitions) and their potential applications (e.g., magnetic hyperthermia, magnetic bioassays, microwave absorbers, anode materials for Li-ion batteries, or solar hydrogen production via water splitting). In FeO/Fe<sub>3</sub>O<sub>4</sub> core/shell nanoparticles both core and shell exhibit magnetic properties, hence, not only is the structural/morphological interface important but also the magnetic arrangement at the interface can play a crucial role in the properties and performance of the nanoparticles. In this work we have revealed two important features to understand the magnetic properties of bimagnetic FeO/Fe<sub>3</sub>O<sub>4</sub> core/shell nanoparticles: i) the temporal evolution over four years of the oxidation front which leads to a final onion-like structure with a graded composition<sup>[1]</sup> and ii) the concomitant appearance of a graded magnetic structure<sup>[2]</sup>. We have demonstrated that the oxidation process reaches to a ‘stand-by’ state owing to the passivation character of the Fe<sub>3</sub>O<sub>4</sub> shell and that the magnetic moment being largest at the surface decreases towards the inner part of the nanoparticle. The elucidation of these results has been addressed by a careful multicharacterization approach based on X-ray diffraction (Whole Powder Pattern Modeling-WPPM, Rietveld refinement, Pair Distribution Function-PDF), Electron Energy Loss Spectroscopy (EELS) and electron Magnetic Circular Dichroism (e-MCD) techniques. Finally, we have also unveiled that for the Fe<sub>x</sub>O<sub>y</sub>/Fe<sub>3</sub>O<sub>4</sub> nanoparticulated system, for small nanoparticles (9 nm) the Fe<sub>x</sub>O<sub>y</sub> core is highly non-stoichiometric and strained leading to the loss of its internal magnetic structure, namely, to the antiferromagnetic behaviour.

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## Cerium - doped Magnetite Nanoparticles: Synthesis and Characterization

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Magnetic iron oxide nanoparticles (NPs), particularly magnetite and maghemite NPs, have attracted significant research interest in the fields of energy, remediation, and biomedicine. Their physicochemical and magnetic properties, and consequently, their applications, depend critically on the size and shape of the crystals. However, most synthetic magnetite is produced through the fast aqueous co-precipitation of Fe<sup>2+</sup> and Fe<sup>3+</sup> ions, where control over nucleation and growth is difficult to achieve, and generally yields small (< 20 nm) superparamagnetic particles. Herein, we present the synthesis of monodisperse ferrimagnetic Fe<sub>3</sub>O<sub>4</sub> nanoparticles prepared by an aqueous co-precipitation method in the presence of citrate and cerium ions, which influence the crystal growth size above 20 nm. By adjusting the synthetic parameters (ion concentration, alkaline titration rate, and temperature), the controlled synthesis of lanthanide-doped magnetite nanoparticles of different sizes can be achieved in aqueous media at room temperature. Magnetic nanoparticles were successfully characterized using HR-TEM/STEM, powder X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and magnetometry analysis. The effects of the experimental parameters on the final product were investigated. The versatility of this synthetic procedure was demonstrated by expanding the use of other lanthanide ions for magnetite doping, thereby demonstrating its capability to obtain similar ferrimagnetic nanoparticles. The synthesis is simple and adaptable for the preparation of lanthanide-doped magnetite nanoparticles, demonstrating its potential for a wide variety of applications.

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## Probing single antiferromagnetic NiO nanoparticles by synchrotron-based X-ray spectromicroscopy

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Nanoscale magnets show a variety of unusual magnetic behaviors when compared to bulk materials, mostly due to surface/interface effects, including symmetry breaking, modified electronic environment and magnetic interactions. NiO nanoparticles (NP) exhibit relevant physical features, such as charge-transfer effects and interesting antiferromagnetic (AF) spin structure. Chemical and magnetic studies are often limited to ensembles of NiO particles which have the disadvantage of averaging out their individual structural, electronic, and magnetic properties with respect to their individual characteristics. Thereby, a deeper and more complete understanding arises from measurements on single NP. Within the framework of a Final Degree Project, we have analyzed with single-particle sensitivity the chemical, and magnetic properties of NiO NP, prepared by wet chemical routes in a size range of 40-60 nm, by means of synchrotron-based X-ray photoemission electron microscopy combined with X-ray Magnetic Linear Dichroism (XMLD). The local X-ray absorption spectra (Fig. 1(a)) reveal variability of the oxidation state of the individual NP depending on the selective oxidation protocol of each sample. By evaluating the XMLD contrast around the Ni L<sub>2</sub> edge with linear polarization versus polarization angle (Fig. 1(b)), our first results indicate different AF spin easy axis orientations between individual NiO NP.

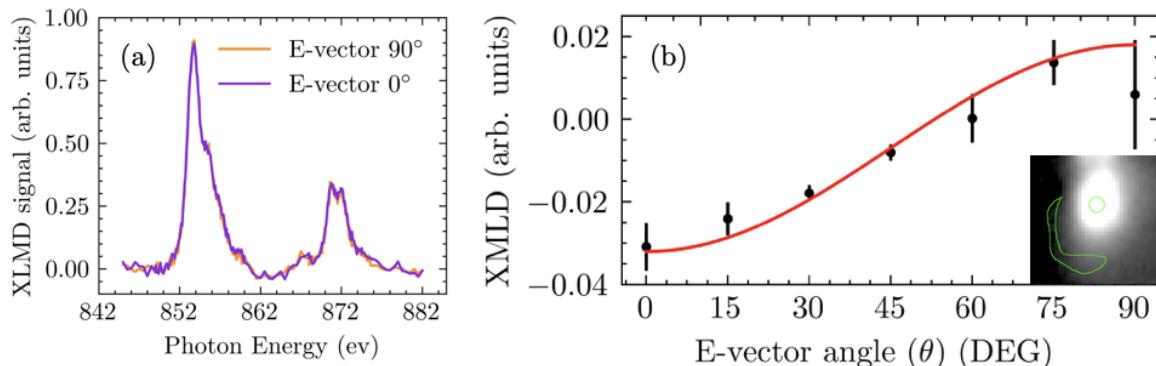


Figure 1. (a) Normalized X-ray absorption spectra of a representative single NiO NP obtained from a stack of X-PEEM images for linear polarization angles of 0° and 90°. (b) XMLD signal from an individual NiO NP (bottom right) as a function of the linear polarization angle fitted with the expected dependency of the AF axis and the polarization angle (solid red line).

## Nanoporous composites prepared using supercritical fluids

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Nanoporous materials possess exceptional structural and surface properties due to the ability to functionalize their pores with a variety of entities, including metal-organic frameworks, metal nanoparticles or polymers.

These materials are characterized by their high surface area and accessibility to a wide range of substances, making them useful for a variety of applications such as drug delivery, catalysis, and pollutant removal. The synthesis of functional porous nanocomposites that involve multiple components and operate synergistically can be challenging.

The SFFM group works on the development of preparation methods that use milder conditions and minimize environmental impact, while also replacing harsh conditions and harmful solvents. Supercritical CO<sub>2</sub> (scCO<sub>2</sub>) technology satisfies these requirements and can often produce nanocomposite porous materials with unique characteristics in terms of morphology, chemical composition, and purity. scCO<sub>2</sub> can act as a reaction solvent, drying agent, or participate in gelation, impregnation of guest molecules, or foaming during the materials preparation process. Our group aims to develop novel porous composites using scCO<sub>2</sub>-assisted methods and demonstrate their potential for emerging applications, particularly focusing on composite materials made of metal-organic frameworks (MOFs) and graphene-oxide (GO) aerogels [1-4]. These materials have pore sizes in the micro to mesoporous range and possess distinct structural and pore arrangements. The obtained materials we tested as catalyst for CO<sub>2</sub> hydrogenation, for mercury removal in contaminated water or materials for gas capture.

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# Electric fields for tuning molecular orientation in TPD-modified glasses: experiments and simulations

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Molecular organic glasses are nowadays gaining attention due to the great advantages they present when used in the electronics industry, such as flexibility, freedom of choice of the underlying layers, low cost, easily control of the thickness and composition and simple fabrication process. However, their lack of efficiency and long-term stability prevent their presence in our daily life. These inconveniences can be solved if those glasses are prepared by Physical Vapour Deposition (PVD) [1]. This technique permits to tune glasses properties by changing the preparation conditions such as the deposition temperature and rate. One of the main assets of PVD is the possibility of obtaining ultrastable glasses, which are special highly-packed glasses that exhibit exceptional thermodynamic and kinetic stability [2], thus improving the efficiency of electronic devices. Another utility of PVD is the possibility of tuning the average spatial orientation of the molecules in the glass, differing from the random distribution that a traditional isotropic glass would have, therefore enhancing the electrical, thermal and optical properties of the glassy materials [3,4]. This two important parameters are strongly linked to the substrate temperature and it is therefore desirable to decouple them in order to obtain ultrastable glasses in which the orientation of its molecules can be chosen as demanded by the final application.

The goal of this study is to change the molecular orientation while maintaining the stability of the glass by applying an electric field during the deposition of TPD and TPD-modified molecules. Ultraviolet-visible spectroscopy [5] will be used for quantifying the degree of anisotropy and the possible changes inferred by the electric field. In addition, Molecular Dynamics simulations have been performed to gain access to the behaviour of each molecule in the glass as well as the possibility of applying electric fields that are not achievable in the laboratory.

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## Glass transition in ultrastable glasses: a close look by means of AFM

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The understanding of glasses and the glass transition is a subject that still needs further research in condensed matter physics. A deeper knowledge of this phenomenon could increase even more the outspread use of glasses in our daily life. In this regard, some years ago it was found that glasses prepared via physical vapour deposition presented exceptional properties compared to glasses prepared from cooling down the liquid. A particularity of these glasses is that, because of their dense packing, they transform into liquid resembling the melting of a crystal. Until now, this phenomenon has only been observed indirectly via calorimetric techniques. In this work, atomic force microscopy will be used to identify the liquid regions formed in the glass. We find that this transition happens via the nucleation and propagation of liquid regions. A wrinkled pattern forms on the surface due to the stress caused by the difference in density between liquid and glass. By following the evolution of this pattern, it is possible to characterize the kinetics of the transformation and extract parameters such as: the nucleation rate, the growth velocity of the liquid regions and the amount of liquid there is as a function of the annealing time.

## Exploring Icosahedral Boron Clusters in Nanomaterials

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Icosahedral boron clusters, carboranes and metallacarboranes, have unique properties as 3-D aromaticity, rigidity, chemical and thermal stability, hydrophobicity or amphiphilicity and low toxicity. They are recognized as good building blocks for the fabrication of nanoscale objects or nanovehicles particularly due to their remarkably planar geometries. All these properties make them useful for a wide range of applications such as materials science, nanotechnology and biomedicine. Our group have developed new methodologies to functionalise boron clusters with the aim to attach them to a huge number of organic molecules, dendrimers, polymers and surfaces (MNPs, CNTs, GO, etc). Linking these clusters to these systems usually produces a great influence on their final properties, allowing to tune these properties what favours their applicability.

In recent years, one of my focus interest has been the design and development of luminescent boron clusters-based molecular materials to study the electronic and steric effect of these boron clusters on the emission properties of attached fluorophores.[1-3] It has been very exciting to discover that depending on the carborane isomer or the way to be attached to the fluorophore, the photoluminescent behaviour of the material can be modified. Thanks to this feature, we have recently prepared highly light emitting water dispersible nanoparticles due to the aggregation induced emission (AIE) phenomenon.[4] Furthermore, we have also prepared carbon-based nanomaterials through the surface functionalization of graphene oxide (GO) with radiolabeled cobaltabis(dicarbollide) units.[5] These nanomaterials can potentially act as theranostic agent for radioimaging and boron carrier for anticancer Boron Neutron Capture Therapy (BNCT).

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## Use of curcuminoids in molecular electronics and as sensors

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The reality of molecular electronics as a basis for future technologies is still in its infancy. Therefore, the creation of new molecular systems and the study of their properties are essential, with the goal of identifying efficient, low-cost, environmentally friendly and high-performance molecular systems at the nano and microscale.

Our group, FunNanoSurf, works with curcuminoids (CCMoids), a family of organic molecules widely studied in the field of biomedicine, but which also have great potential for application in other research areas within nanoscience and nanotechnology. This is due, in part, to their chemical versatility, being able to be used as molecular platforms for the creation of multifunctional molecular-based systems. Specifically, this work aims to highlight single-electron transport studies performed with CCMoids, as nanowires, inserted into Au and graphene electrodes. Also, how we use molecular design to control the deposition of our molecules on different surfaces and their use as sensors[1-5]. This talk briefly summarizes our most relevant findings to give an overview of possible and future applications of CCMoids.

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## Spintronics in novel quantum materials: interfacial phenomena

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The term quantum materials has been coined to describe a wide range of matter, from unconventional superconductors and heavy fermions to topological quantum matter, two-dimensional (2D) materials and their van der Waals heterostructures, just to cite a few. 2D and topological materials are particularly interesting for dissipationless electronics due to their unique spin-dependent properties as a result of their large spin-orbit coupling (SOC) properties. Exploitation of the huge spintronic potential in these materials will provide new opportunities of achieving control and manipulation of spin transport in hybrid structures [1]. In this talk, I will describe the importance of interfacial phenomena in heterostructures with large SOC topological and 2D materials that could be incorporated into spintronic devices. Firstly, I will describe our results in systems combining topological insulators and ferromagnetic materials [2]. Secondly, I will focus on hybrid structures of 2D materials [3]. In both cases, the use of advanced characterization techniques, such as x-ray absorption spectroscopy in synchrotron radiation facilities, and laboratory-based spin-torque ferromagnetic resonance, have provided unparalleled information about magnetic proximity effects and spin phenomena at their interfaces.

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## 2-dimensional materials at the interfaces of spintronic devices

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The introduction of 2-dimensional (2D) materials in heterostructures for spintronics devices is of particular relevance due to the fact that they naturally provide sharp interfaces with unique properties and the performance of spintronic devices is greatly dependent on interfacial properties.

In particular, we will show how the insertion of a 2D material such as graphene or h-BN in magnetic tunnel junctions (grown directly on top of a ferromagnet) can lead to large tunnel magnetoresistance and spin-filtering effects, which can be attributed to different coupling of the 2D layer and the contiguous ferromagnet [1,2].

We will also discuss a recent work in which we succeeded in using transferred graphene grown by chemical vapor deposition to protect a surface from oxidation and to avoid intermixing, a common problem in such heterostructures [3].

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## Advanced Processing of Epitaxial Graphene grown on SiC for the Fabrication of Top-Gated Graphene FETs

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The implementation of graphene in the existing semiconductor technology, was considered to be one solution for the limitations found in Si and achieving future-generation electronics [1]. The realization of those devices with the most effective performance is based on the optimization in the steps of the production, manipulation, and processing of graphene materials. A most challenging factor is the preservation of the high quality of graphene e.g. when transferring it to the desired substrate for the processing, while being able to address arbitrary device architectures. In this report, the fabrication and characterization of epitaxial graphene (EG) on the C-face of SiC and its transfer on SiO<sub>2</sub> substrate by a novel electrochemical bubbling delamination technique is thoroughly examined [2]. The imaging and structural characterization showed that the good properties of single crystal graphene flakes are preserved upon transfer. Based on these isolated flakes, graphene field effect transistors (FETs) are fabricated by three patterning levels with electron beam lithography (EBL). The nanofabrication includes a locally-patterned cross-linked PMMA as the dielectric layer for a FET top gate configuration. Whereas insulating functionality is bad at RT, it works at -10°C, and allowed to observe charge density modulations by electrical gating.

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## Tunable BaMO<sub>3</sub> (M= Ti, Zr and Hf) Nps used on CSD approach to YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-δ</sub> superconducting layers

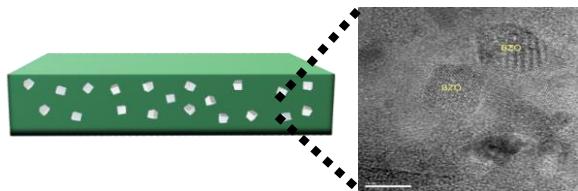
Susagna Ricart<sup>a</sup>, Naatalia Chamorro<sup>a,b</sup>, Diana Franco<sup>a</sup>, Cornelia Pop<sup>a</sup>, Ramon Yáñez<sup>b</sup>, Anna Palau<sup>a</sup>, , Xavier Obradors<sup>a</sup>, Teresa Puig<sup>a</sup>

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Nowadays the target of being able to control size, morphology, or composition from the metal oxide NPs has raised the interest for further application such as medicine, materials science and electronic devices. Here, we shown a novel, scalable and reproducible synthetic procedure for a wide spectrum of binary metal oxide NPs as ABO<sub>3</sub> (A= Ba, Sr and B= Ti, Hf, Zr) and BaM<sub>2</sub>O<sub>6</sub> (M= Ta, Nb). Using modified polyol route in solvothermal conditions small-sized, non-aggregated, crystalline, homogenous and dispersed NPs have been obtained. The fast and scalable method developed for this family of metal oxide NPs make them interesting for many applications, focusing on the fabrication of superconducting nanocomposites of YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-δ</sub> (YBCO) High Temperature Superconductor (HTS) by Transient Liquid Assisted Growth (TLAG) Chemical Solution Deposition (CSD) low-cost approach. Good superconducting properties have been obtained starting from colloidal solutions of the preformed oxide nanoparticles.



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## TEM analysis for Thin-Film Ferroelectric Orthorhombic $\alpha$ -Pr<sub>2</sub>WO<sub>6</sub> Polymorph

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A Ferroelectric orthorhombic  $\alpha$ -Pr<sub>2</sub>WO<sub>6</sub> (PrWO) polymorph were obtained in the form of thin film by pulsed laser deposition on (100)-oriented SrTiO<sub>3</sub> substrates. A combination of different techniques were used to characterize this new lead-free material, where the X-ray analysis indicated an orthorhombic structure with  $a = 16.57(5)$  Å,  $b = 5.52(5)$  Å, and  $c = 8.73(1)$  Å. The transmission electron microscopy (TEM) analysis showed the orientations [100]PrWO || [110]STO and [010]PrWO || [110]STO in the plane, where the PrWO layer thick is 36 nm and [001] growth direction. TEM analysis also revealed the presence of superstructure related to domains. Additionally, the stability of this polymorph in thin film up to 900 °C was demonstrated by X-ray thermodiffraction measurements, and spectroscopic ellipsometry measurements indicated a band gap of 2.5 eV in such 36nm thick films. This study demonstrates the existence of a new lead-free ferroelectric material in the series of  $\alpha$ -Ln<sub>2</sub>WO<sub>6</sub> (lanthanide) tungstates, which can be considered as a promising candidate for applications in both nanoelectromechanical and energy-harvesting systems as well as for integrating optics.

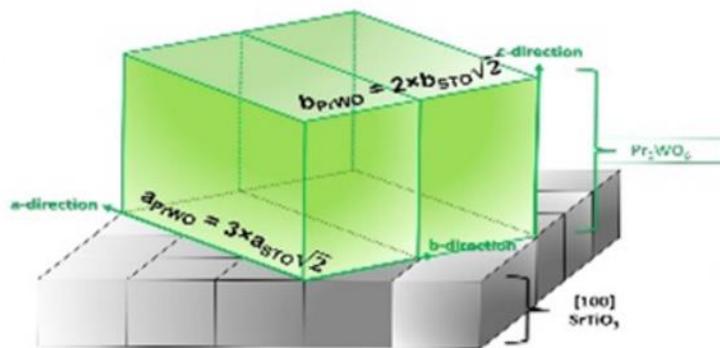


Figure 1: Thin film schematic drawing for PrWO//STO thin film.

## Caracterización, modelización y simulación de memristores basados en estructuras MIM

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El memristor es considerado uno de los 4 componentes pasivos que podemos encontrar en los circuitos eléctricos. Fue vaticinado por Chua en 1971 y se le denomina así por ser una resistencia eléctrica con memoria [1]. Su resistencia depende de la corriente que ha fluido previamente por él y se puede modular mediante la aplicación de impulsos eléctricos. Estos dispositivos generalmente están basados en estructuras MIM (metal-aislante-metal). El principal mecanismo físico responsable de su comportamiento, es el fenómeno de la conmutación resistiva, el cual consiste en la formación y destrucción de un filamento conductor nanométrico en el dieléctrico por la acción de un campo eléctrico. Estos nano-filamentos están compuestos por defectos químicos y estructurales que dependen, en gran medida, de las combinaciones y propiedades de los materiales que forman parte del dispositivo MIM. El memristor es un excelente candidato para substituir a las memorias convencionales, es escalable, de bajo consumo y rápido. También se puede utilizar en aplicaciones de encriptación, comunicación y redes neuromórficas [2].

El trabajo que se presenta está centrado en la caracterización eléctrica del comportamiento de conmutación resistiva de memristores basados en estructuras TiN/Ti/HfO<sub>2</sub>/W [3] obtenidas bajo diferentes condiciones de fabricación. Los resultados han permitido optimizar el proceso de fabricación para obtener un mayor rendimiento de los dispositivos [4]. Por otro lado, para complementar el estudio eléctrico, se han realizado inspecciones físicas mediante microscopio electrónico. Finalmente, la respuesta eléctrica de los dispositivos se ha analizado mediante el modelo de memdiodo quasiestático (QMM) [5] y dinámico (DMM) utilizando el simulador circuital LTSPICE [6].

### References

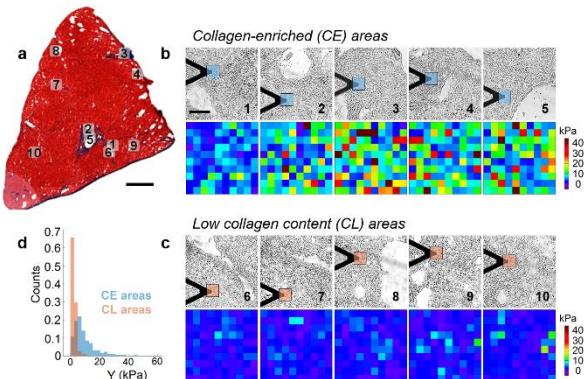
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# Spatial mapping of cells and tissues properties at small scales by AFM

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Changes in the elastic properties of living tissues and cells during normal development and in pathological processes are challenging to assess at small scales. They could give very new information to pathologists and doctors while assessing illnesses and can constitute new markers for diagnostics and drug screening. Force volume atomic force microscopy (AFM) can precisely capture the mechanical properties of biological samples with force sensitivity and spatial resolution. The integration of AFM data with data of the molecular composition contributes to understanding the interplay between tissue biochemistry, organization and function. In my work, I detected micrometer-size, heterogeneous domains at different elastic moduli in tissue sections and I used the AFM to identify collagen-enriched domains, naturally present in human and mouse tissues by their elastic modulus. Collagen identification is obtained in a robust way and affordable timescales, through an optimal design of the sample preparation method and AFM parameters for faster scan with micrometer resolution. The choice of a separate reference sample stained for collagen allows correlating elastic modulus with collagen amount and position with high statistical significance. This approach can be extended to characterize cancer cell phenotypes and other types of biological samples.



## Super resolution microscopy applied to nanomedicine

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We use advanced microscopy techniques to visualize and track in living cells and tissues self-assembled nanomaterials with therapeutic potential. The understanding of materials-cell interactions is crucial towards the development of novel nanotechnology-based therapies for treatment of cancer and infectious diseases.

We work with novel bioactive materials such as nanoparticles or peptide-based nanofibers able to build themselves. To study the behavior of such complex nanomaterials in action we make use of a variety of optical microscopy techniques, in particular super resolution microscopy (SRM).[1,2] SRM can achieve a resolution down to 5 nm and represents an ideal tool to visualize nanosized objects in the biological environment. In particular we demonstrate how STORM (Stochastic Optical Reconstruction Microscopy) or PAINT (Point Accumulation for Imaging in Nanoscale Topography) can be used to image a wide range of nanomaterials beyond the diffraction limit, allowing this observation in the biological environment.

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## 3D printing technologies for the development of living robotics

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Soft robotic systems often present bio-mimicking designs that resemble actuation mechanisms of certain biological organisms, as for example in swimmers resembling fish or flagellated organisms. However, some unique properties from living organisms that are specially challenging to obtain in their artificial counterparts, such as self-healing, adaptability, or bio-sensing capabilities.[1] Several bio-hybrid robotics platforms across different scales had been developed,[2] but the ones based on living muscles has attracted increasing attention.[3] 3D printing technologies allowed the fabrication of advanced living robots based on skeletal muscle cells,[4] exploring new designs that are not bio-mimetic but really efficient, but also integrating nanomaterials for enhanced force output.[5] Although extrusion-based 3D printing techniques had been the preferred ones due to increased cell alignment during the printing process, other 3D printing techniques are desired to generate such living robots either at bigger or smaller scales. The key feature when designing these new generation of robots using living components as an active material will be discussed, as well as the main challenges and applications, both in the biomedical and the environmental field.

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## La vuelta al cole de una *nanoexperta*

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El proyecto Nanoinventum arrancó en el año 2017 con el objetivo de incorporar la ciencia y la nanotecnología en la enseñanza primaria, concretamente, en el ciclo superior (de cuarto a sexto curso). El proyecto sigue la metodología didáctica STEAM, acrónimo de Science, Technology, Engineering, Arts and Mathematics. A su vez, trabaja conceptos de sostenibilidad, forma al profesorado y busca vincular el aprendizaje con el currículum científico de las escuelas.[1]

El alumnado participante se familiariza con el lenguaje y el método científico mientras que, por otro lado, se inicia en el campo de la nanotecnología y su impacto en el mundo que nos rodea.

Nanoinventum se divide en cuatro fases, centrándose sobre todo en el aula:

Fase 1: Formación del profesorado. Se introducen conceptos de nanotecnología, nanoescala, aplicaciones nano, nanorobots, sostenibilidad y creatividad.

Fase 2: Trabajo en el aula con el maletín NanoExplora.[2]

Fase 3: Creación de una maqueta-nanorobot.[3]

Fase 4: Presentación de las maquetas en una gran feria final.

Es en la fase 3 cuando las denominadas *nanoexpertas* (científicas que desarrollan su investigación en el campo de la nanociencia) les visitamos y les asesoramos en la construcción de dichas maquetas. Sin embargo, la labor de una nanoexperta va mucho más allá de esta ayuda. Nuestra visita a sus aulas supone el primer *acercamiento* que los escolares tienen a una científica, la que disfruta observando sus muestras bajo el microscopio y se emociona al hablar de sus descubrimientos, y también la que después se quita la bata y se va al cine con su familia o que cada día compra en la tienda de la esquina.

En esta charla compartiré mi experiencia personal como nanoexperta de Nanoinventum y reflexionaré con la audiencia sobre cómo una idea tan sencilla de implementar puede tener un impacto real y muy positivo en las generaciones futuras.

### Referencias

- [1] Proyecto Nanoinventum: <https://www.nanoinventum.com> (Último acceso 12/01/2023)
- [2] Maleta Nanoexplora: <https://blocs.xtec.cat/cesirenanotecnologia/> (Último acceso 12/01/2023)
- [3] Blog NanoInventum: <http://nanoinventum.blogspot.com/p/inicio.html> (Último acceso 12/01/2023)

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