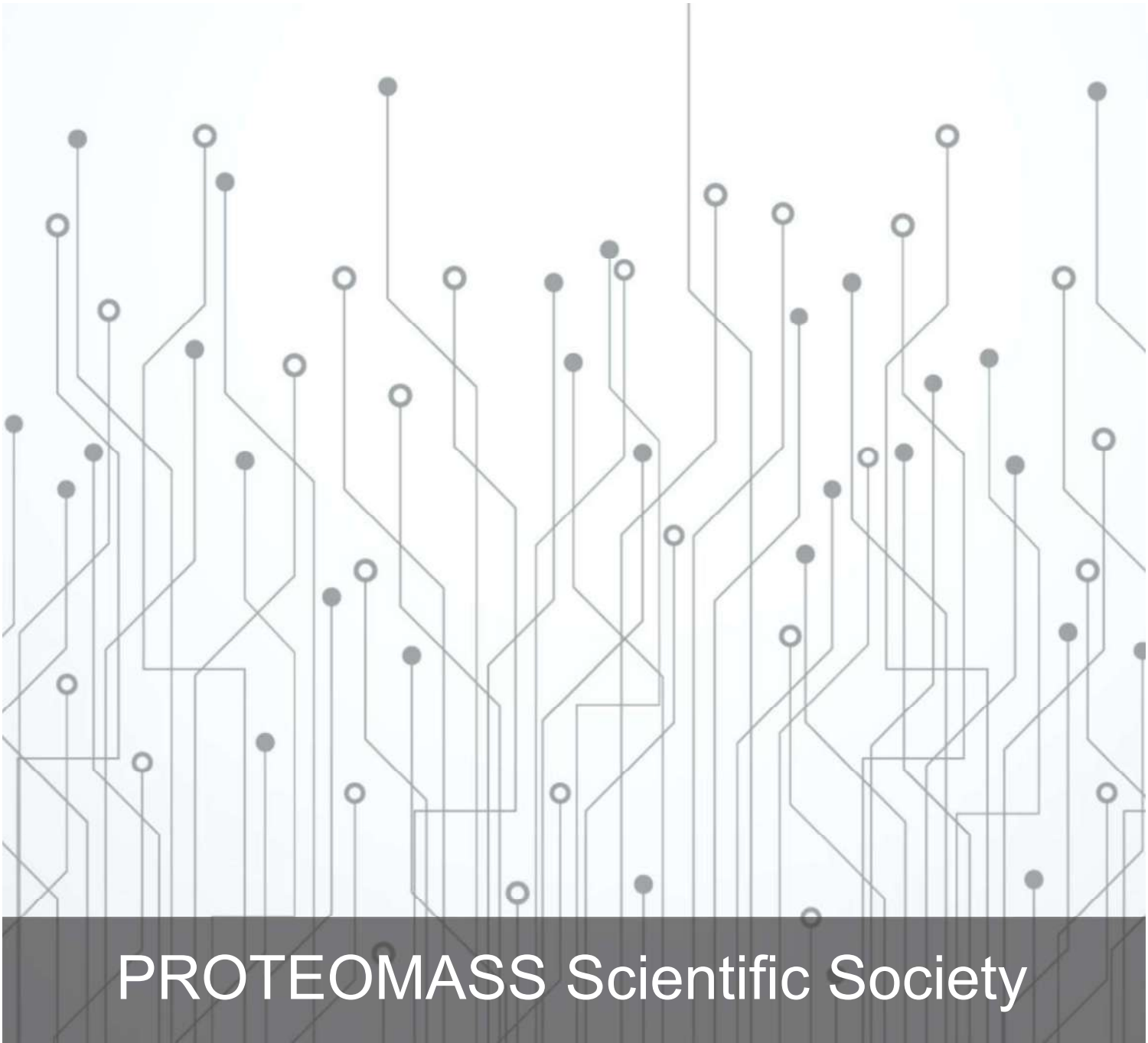
ULTRASONICS 2021

5th International Caparica Conference on Ultrasonics-based Applications: From Analysis to Synthesis

CAPARICA, PORTUGAL / 31TH MAY - 03RD JUNE 2021



PROTEOMASS Scientific Society

ULTRASONICS 2021 Proceedings Book

5th International Caparica Conference on Ultrasonic-based Applications: from analysis to synthesis 2021

Caparica – Portugal
31th – 03rd June 2021

5th International Caparica Conference on Ultrasonic-based Applications: from analysis to synthesis 2020

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Caparica - Portugal, 2021

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Programme by day

MIND: THE TIME IS LISBON-BASED (UTC +1)

Monday | May 31th		
ZOOM:	**https://us02web.zoom.us/j/83445356381?pwd=bGVneXZrYnJTekovNTZzL3R2Qnd0QT09**	
Meeting ID:	**834 4535 6381**	
Password:	**887862**	
Chairperson:		José L. Capelo
14:00 - 14:15		Oppening Sesion
14:15 - 14:30		**Plenary Lecture 1.** ***Aharon Gedanken (Israel)***
14:30 - 14:45	O.01	***Mohammed Es Souni (Germany)***
14:45 - 15:00	O.02	***Viktor Chikan (USA)***
15:00 - 15:15	O.03	***Damiano Palmieri (Italy)***
15:15 - 15:35		***Coffe Break***
Chairperson:		Hugo M. Santos
15:35 - 15:40	SG.01	***Aarón Terán More (Spain)***
15:40 - 15:45	SG.02	***Elisabetta Tortorella (Italy)***
15:45 - 15:55	SG.03	***Luis Carvalho (Portugal)***
15:55 - 16:00	P.01	***Angela Ditri (Itay)***
16:00 - 16:05	P.02	***Damiano Palmieri (Italy)***

Tuesday | June 01st		
ZOOM:	**https://us02web.zoom.us/j/83373874301?pwd=L3piRmI5Y2hFNzlDVlBiblZLd3dvdz09**	
Meeting ID:	**833 7387 4301**	
Password:	**330151**	
Chairperson:		José L. Capelo
10:00 - 10:15		Keynote 1 ***Glen Harris (Australia)***
10:15 - 10:25	O.04	***Norio Tagawa (Japan)***
10:25 - 10:35	O.05	***Maxim Solovchuk (Taiwan)***
10:35 - 10:45	O.06	***Ioan Calinescu (Romania)***
10:45 - 10:55	O.07	***Paolo Guida (Saudi Arabia)***
10:55 - 11:05	O.08	***Christian David (France)***
		Break
Chairperson		José L. Capelo
13:00 – 13:10	O.09	***Grzegorz Musielak (Poland)***
13:10 – 13:20	O.10	***P.L.M.J. van Neer (Netherlands)***
13:20 – 13:30	O.11	***Richard J Colchester (UK)***
13:30 - 13:40	O.12	***Lars Grüter (Germany)***
13:40 – 14:00		***Break***
Chairperson:		José L. Capelo & Hugo M. Santos
		POSTER SESSION
14:00 – 14:05	P.03	***Jose Maria Palacios Santander (Spain)***
14:05 – 14:10	P.04	***Laura Cubillana Aguilera (Spain)***
14:10 – 14:15	P.05	***Adina Ionuta Gavrila (Romania)***
14:15 – 14:20	P.06	***Gordana Zauhar (Croatia)***
14:20 – 14:25	P.07	***Oleg Olikh (Ukraine)***
14:25 – 14:30	P.08	***A.V. Morozova (Russia)***
14:40 – 15:00		***Break | Conference Picture (Zoom)***
Chairperson:		José L. Capelo
15:00 - 15:15		**Plenary Lecture 2. *Kullervo Hynynen (Canada)***
15:15 - 15:30		**KPRK Talk. *Aaron Fenster (Canada)***
15:30 – 15:40	O.13	***Reine-Marie Guillermic (Canada)***
15:40 - 15:50	O.14	***R. Amadeus Mason (USA)***
15:50 - 16:00	O.15	***Arnaldo T. Soltermann (Argentina)***
16:00 - 16:15	O.16	***Marco Alunno (Colombia)***
16:10 - 16:20	O.17	***Jean Gabriel Minonzio (Chile)***

Wednesday | June 02nd		
ZOOM:	**https://us02web.zoom.us/j/84516767034?pwd=akIrcHplVUhCZ1Z2ZTNmSGd5QmxYQT09**	
Meeting ID:	**845 1676 7034**	
Password:	**058572**	
Chairperson:		José L. Capelo
10:00 - 10:15		**Plenary Lecture 3. Jürgen Götz (Australia)**
10:15 - 10:30		**Keynote 2 *Mohsen Gavahian (Taiwan)***
10:30 - 10:40	O.18	***Maja Rosič (Slovenia)***
10:40 - 10:50	O.19	***Miaomiao Zhang (Belgium)***
10:50 – 11:00	O.20	***Ivan Suarez-Castellanos (France)***
Chairperson:		José L. Capelo
13:00 – 13:15		**Plenary Lecture 4. *Gail Ter Haar (UK)***
13:15 – 13:25	O.21	***Gabriel M. Gurman (Israel)***
13:25 – 13:35	O.22	***Federica Foglietta (Italy)***
13:35 – 13:45	O.23	***Dominik Mierzwa (Poland)***
13:45 – 14:00		*Break*
Chairperson:		Hugo M. Santos
14:00 – 14:15		**Plenary Lecture 5. *Brijesh Tiwari (Ireland)***
14:15 – 14:30		**Keynote 3 *Mikhail Skliar (USA)***
14:30 – 14:40	O.24	***Małgorzata Nowacka (Poland)***
14:40 - 14:50	O.25	***Gerard Verbiest (Netherlands)***
14:50 – 15:00		*Break*
Chairperson:		José L. Capelo & Hugo M. Santos
		SHOTGUN SESSION / POSTER PRESENTATION
15:00 - 15:05	SG.04	***Vincent Jacquemain (France)***
15:05 - 15:10	SG.05	***Christophe Cheuleu (France)***
15:10 - 15:15	SG.06	***Raissa Likhonina (Czech Republic)***
15:15 – 15:20	SG.07	***Katarzyna Rybak (Poland)***
15:20 – 15:25	SG.08	***N.S. Shaitura (Russia)***
15:25 – 15:30	SG.09	***Watbled Bastien (France)***
15:30 – 15:35	SG.10	***Elisa Porchietto (Italy)***
15:35 – 15:40	SG.11	***Magdalena Grzegorczyk (Poland)***
15:40 – 15:45	P.09	***Dominik Mierzwa (Poland)***
15:45 - 16:00		**Keynote 4 *Xueding Wang (USA)***

Thursday | June 03rd		
ZOOM:	**https://us02web.zoom.us/j/87681548170?pwd=cnVVcS8xSWRGWXNBVjJFK1JCM2ppZz09**	
Meeting ID:	**876 8154 8170**	
Password:	**748803**	
Chairperson:	José L. Capelo	
10:00 - 10:15	**Plenary Lecture 6. *Parag Gogate (India)***	
10:15 - 10:25	O.26	***Palacios Santander (Spain)***
10:25 - 10:35	O.27	***Sacha Noimark (UK)***
10:35 - 10:45	O.28	***Dmitry A. Ivlev (Russia)***
10:45 - 10:55	O.29	***Shen Zhi Yong (China)***
	Break	
Chairperson:	José L. Capelo & Hugo M. Santos	
14:00 - 14:10	O.30	***Ivan Mikheev (Russia)***
14:10 - 14:20	O.31	***Erik Persson (Sweden)***
14:20 - 14:30	O.32	***Jahan Azizi (USA)***
14:30 - 14:40	O.33	***Hong Chen (USA)***
14:40 - 14:50	O.34	***Aleem M. Siddiqui (USA)***
Chairperson:	José L. Capelo & Hugo M. Santos	
14:50 - 15:05	Keynote 5. ***Hubert Lim (USA)***	
15:05 - 15:20	Plenary 7. ***Jan D'hooge (Belgium)***	
15:20 - 15:35	Plenary 8. ***Andreas Mandelis (Canada)***	
15:35 - 16:00	*Closing Session & Awards Ceremony*	

General Information

Conference Language
English is the ULTRASONICS 2021 official language. No simultaneous translation is provided.

Certificate of Attendance
The Certificate of Attendance will be sent to the delegates by e-mail.

Liability and Insurance
Registration fees do not include participants insurance against personal accidents, sickness and cancellations by any part, theft, loss or damage to personal possessions. ULTRASONICS 2021 and the Organization Secretariat accept no liability. Any dispute about payment and participation shall be governed and interpreted according to the laws of that in Portugal: The parties irrevocably submit to the jurisdiction of the courts of Portugal (Lisbon metropolitan area) with respect to all disputes or matters arising out of or pertaining to the participation in this conference (ULTRASONICS 2021).

Program Changes
Due to circumstances beyond the control of the Organization and ULTRASONICS 2021, last minute changes to the programme may be unavoidable. All the information in this program is accurate as at the day of printing (May 21th, 2021).

Disclosure of Information
Proceedings Book is avalibale for downloade at the conference website www.ultrasonics2021.com

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Monday, May 31st

Jose Luis Capelo Martinez's Zoom Meeting

Scheduled: 31 May 2021 at 09:00 to 21:00 WEST
Location
https://us02web.zoom.us/j/83445356381?pwd=bGVneXZrYnJTekovNTZzL3R2Qnd0QT09

Jose Luis Capelo Martinez is inviting you to a scheduled Zoom meeting.

Topic: Jose Luis Capelo Martinez's Zoom Meeting

Time: May 31, 2021 09:00 AM Lisbon
Join Zoom Meeting

https://us02web.zoom.us/j/83445356381?pwd=bGVneXZrYnJTekovNTZzL3R2Qnd0QT09

Meeting ID: 834 4535 6381

Passcode: 887862

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Dial by your location
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+1 253 215 8782 US (Tacoma)
Meeting ID: 834 4535 6381
Passcode: 887862
Find your local number: https://us02web.zoom.us/u/ky6EoAnUY

Tuesday, June 01st

Jose Luis Capelo Martinez's Zoom Meeting

Scheduled: 1 Jun 2021 at 09:00 to 21:00, WEST

Location: https://us02web.zoom.us/j/83373874301?pwd=L3piRmI5Y2hFNzlDVlBiblZLd3dvdz09
Jose Luis Capelo Martinez is inviting you to a scheduled Zoom meeting.

Topic: Jose Luis Capelo Martinez's Zoom Meeting

Time: Jun 1, 2021 09:00 AM Lisbon

Join Zoom Meeting
https://us02web.zoom.us/j/83373874301?pwd=L3piRmI5Y2hFNzlDVlBiblZLd3dvdz09

Meeting ID: 833 7387 4301
Passcode: 330151
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+1 253 215 8782 US (Tacoma)
Meeting ID: 833 7387 4301
Passcode: 330151
Find your local number: https://us02web.zoom.us/u/kbg9YXcRHt

Wednesday, June 02nd

Jose Luis Capelo Martinez's Zoom Meeting

Scheduled: 2 Jun 2021 at 09:00 to 21:00, WEST

Location: https://us02web.zoom.us/j/84516767034?pwd=akIrcHplVUhCZ1Z2ZTNmSGd5QmxYQT09

Jose Luis Capelo Martinez is inviting you to a scheduled Zoom meeting.

Topic: Jose Luis Capelo Martinez's Zoom Meeting

Time: Jun 2, 2021 09:00 AM Lisbon

Join Zoom Meeting
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Find your local number: https://us02web.zoom.us/u/kd5M8yA3Da

Thursday, June 03rd

Jose Luis Capelo Martinez's Zoom Meeting

Scheduled: 3 Jun 2021 at 09:00 to 21:01, WEST

Location: https://us02web.zoom.us/j/87681548170?pwd=cnVVcS8xSWRGWXNBVjJFK1JCM2ppZz09
Jose Luis Capelo Martinez is inviting you to a scheduled Zoom meeting.

Topic: Jose Luis Capelo Martinez's Zoom Meeting

Time: Jun 3, 2021 09:00 AM Lisbon

Join Zoom Meeting
https://us02web.zoom.us/j/87681548170?pwd=cnVVcS8xSWRGWXNBVjJFK1JCM2ppZz09

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Find your local number: https://us02web.zoom.us/u/kdEAlUk6Z9

Awards

Best Poster Prizes

PROTEOMASS Scientific Society will award the two-best poster communications with a certificate from the PROTEOMASS Scientific Society. The Criteria for eligibility will be based on the excellence and originality of the research presented. Selection will be done by an online voting. To receive the prize is mandatory attend the Closing Session & Awards Ceremony, Thursday, June 03th 15:35.

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Best Shotgun and Shotgun Poster Prizes

PROTEOMASS Scientific Society and the Start up Nanoarts

Will award the 2 best shotgun communications and the 2 best shotgun poster communications with a certificate from the PROTEOMASS Scientific Society. The Criteria for eligibility will be based on the excellence and originality of the research presented. Selection will be done by an online attendee voting. To receive the prize is mandatory attend the Closing Session & Awards Ceremony, Thursday, June 03th 15:35.

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VOTE FOR BEST POSTERS & SHOTGUNS

Best Poster Prizes – Session I P01 – P09

Tuesday, June 02nd | 14:10 – 14:40 pm

VOTE FOR YOUR FAVOURITE POSTERS!

These prizes will be given to the two best posters presented at the conference. It rewards a combination of excellent research, innovation, and presentation. Poster presentation winners will be recognized publicly in the Closing Session & Awards Ceremony, Thursday, June 03th 15:35.

The winners will receive a certificate by PROTEOMASS Scientific Society.

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Best Shotgun Presentation Prizes

Wednesday, June 02nd | 15:05 – 16:00 pm

VOTE FOR YOUR FAVOURITE SHOTGUN PRESENTATION!

These prizes will be given to the two best Shotgun communications presented at the conference. It rewards a combinati on of excellent research, innovation, and presentation. Shotgun presentati on winners will be recognized publicly in the Closing Session & Awards Ceremony, Thrusday, June 03th 15:35 pm.

The winners will receive a certificate by PROTEOMASS Scientific Society.

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https://forms.gle/omUWW6vkqfGxGRNq5

Best Shotgun Poster Prizes

Tuesday, June 02nd | 14:10 – 14:40 pm

VOTE FOR YOUR FAVOURITE SHOTGUN POSTER!

These prizes will be given to the two best Shotgun posters presented at the conference. It rewards a combination of excellent research, innovation, and presentation. Shotgun presentati on winners will be recognized publicly in the Closing Session & Awards Ceremony, Thrusday, June 03th 15:35 pm.

The winners will receive a certificate by PROTEOMASS Scientific Society.

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Welcome

PREFACE to the 5th International Caparica Conference on Ultrasonic-based Applications: from analysis to synthesis 2021, Ultrasonics 2021

José-Luis Capelo-Martínez, Carlos Lodeiro, Hugo M. Santos

BIOSCOPE Research Group, LAQV, REQUIMTE, Department of Chemistry, Faculdade de Ciências e Tecnología, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal. PROTEOMASS Scientific Society, Madan Park, Rua dos Inventores, 2825-152 Caparica, Portugal.

The piezoelectric effect was first described by Jacques and Pierre Curie in 1880 [1]. Since then, the technology related to ultrasound has growth to applications the own Curie brothers would have never envisioned. For instance, the business for ultrasonic sensors makes part of a market that is growing at a ratio of 19% every year [2], with an estimated global value of about $60 billion by 2022. Ultrasonic sensors are currently used (i) in wind sensors to calculate wind speed and help in mapping the weather; (ii) in monitoring metal corrosion in a non-invasive manner; (iii) in helping fire extinguisher robots to detect hotspots; (iv) in searching and rescue operations and (v) in remediating water contaminated with toxic algae, just to mention five applications. Indeed, food industry, design of new materials, environmental applications, chemical analysis and chemical synthesis are some of the areas where ultrasound is gaining momentum. Personally, I consider the applications in medicine the most amazing ones, especially the ones related to the brain. In 2016 the American FDA approved the focused ultrasound thalamotomy as a treatment for people having a movement disorder called essential tremor [3]. And the applications can go beyond, as it is expected to be applied in intractable neuropsychiatric disorders, such as depression and anxiety. Also, in Parkinson´s disease. Ultrasound energy can be targeted with high precision in deep regions of the brain, where no other techniques can be used. Some colleagues think ultrasound can be used to tune the brain by stimulating the cells and more interestingly, ultrasound waves can be used to expand nanoparticle drug carriers make them deliver the cargo in precise brain areas. Taking together, we are going to enjoy all the 2021 presentations, from engineering to medicine, from food processing to environmental applications.

I cannot finish this welcome without a reference to the exceptional circumstances of 2020 and 2021. For the second time, and I do hope the last one, we are not going to be all face-to-face. I am deeply grateful to all of you, for participating and for your support in this severe moment.

I speak on behalf of the bioscope team when I say we are waiting to make a triple toast face to face during the gala dinner of ultrasonics 2023, one for 2020, one for 2021 and another one for 2023 ultrasonic editions.

Take care and stay safe.

J. L. Capelo, C. Lodeiro, H. M. Santos

On behalf of the bioscope group.

[1] Curie, Jacques; Curie, Pierre (1880). "Développement par compression de l'électricité polaire dans les cristaux hémièdres à faces inclinées" [Development, via compression, of electric polarization in hemihedral crystals with inclined faces]. *Bulletin de la Société Minérologique de France*. **3** (4): 90–93. doi:10.3406/bulmi.1880.1564.
[2] https://www.porttechnology.org/news/ultrasonic_sensors_mapping_the_future/, last time accessed July, the 5th, 2020
[3] https://www.nature.com/articles/d41586-017-05479-7, last time accessed July, the 9th, 2020.

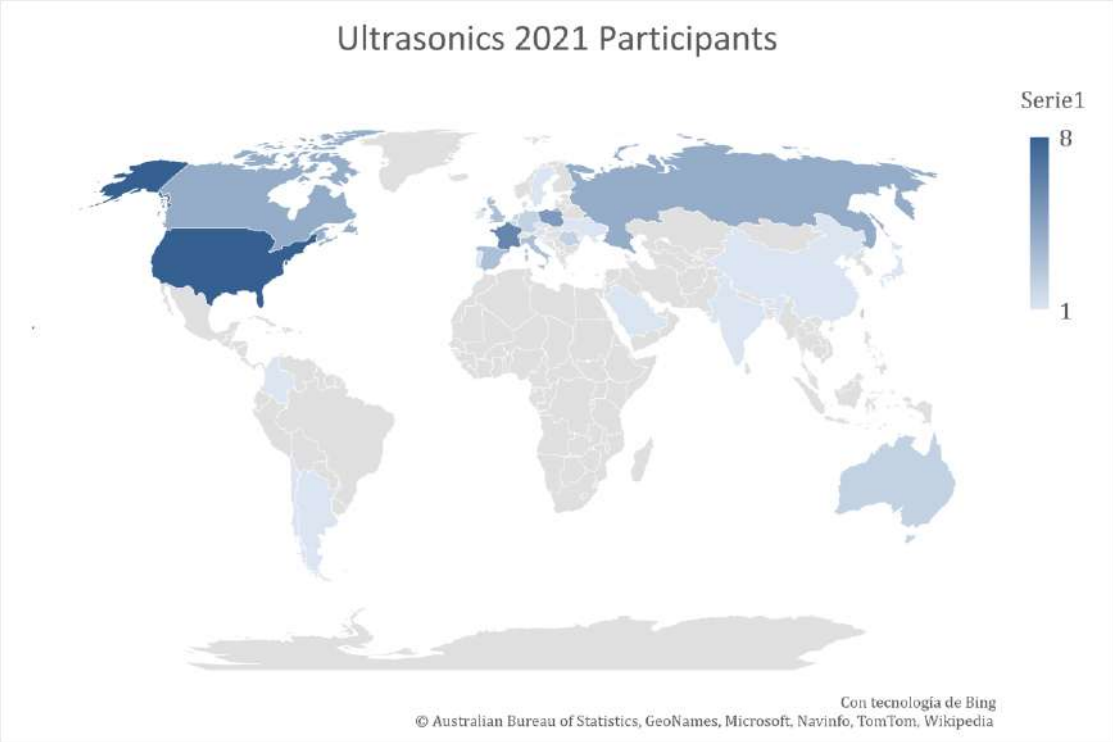

Figure 1 – Participants at the Ultrasonics 2021

Largest delegations: United States of America (7), France (6), Poland (5)

ULTRASONICS 2018 CONFERENCE PICTURE

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Plenary Lectures

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Jürgen Götz

Clem Jones Centre for Ageing Dementia Research (CJCADR), Queensland Brain Institute (QBI), The University of Queensland, St Lucia Campus (Brisbane), QLD 4072, Australia

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Physiological and pathological ageing (exemplified by Alzheimer's disease) are characterized by a progressive decline that also includes cognition. Whether this decline can be slowed or even reversed remains to be determined. Here, we discuss therapeutic ultrasound as a modality to address this question. In our studies, we explored three fundamental modalities, scanning ultrasound on its own (SUSonly), therapeutic ultrasound interacting with intravenously injected microbubbles (which transiently opens the blood-brain barrier, SUS+MB), and SUS+MB in combination with therapeutic antibodies (SUS+MB+mAb). SUS+MB effectively clears amyloid and restores memory in amyloid-depositing mice, and partially clears tau and ameliorates memory impairments in tau transgenic mice, with additional improvements by a combination trial (SUS+MB+mAb). Interestingly, SUSonly or SUS+MB applied to senescent wild-type mice restores the induction of long-term potentiation (LTP), an electrophysiological correlate of memory. Both modalities lead to increased neurogenesis, and in particular SUSonly, which was more extensively analysed, resulted in improved spatial memory in the senescent mice. We will put these findings into perspective by discussing them side-by-side with findings obtained in Alzheimer's mouse models. We conclude that therapeutic ultrasound is a non-invasive, pleiotropic modality that may not only present a treatment option for Alzheimer's disease, but also enhance cognition in physiological ageing.

PL 4 - Therapy Ultrasound : who needs a focus?

Gail ter Haar

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The Institute of Cancer Research

London, UK

Ultrasound's therapeutic applications predate those for diagnosis by at least a decade. Although there was an early interest in using high intensity focused beams for brain studies, by far more investigations involved lower intensity unfocused devices for treating a wide range of malignant and benign conditions. The development of these techniques will be reviewed, and their current status discussed.

PL 5 - Brijesh Tiwari

PL 6 - Process intensification of chemical processing applications using cavitational reactors: design, scale up and applications

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Abstract:

Cavitational reactors are a novel and promising form of multiphase reactors, based on the principle of release of large magnitude of energy due to the violent collapse of the cavities. Use of cavitational reactors for process intensification of several chemical and physical processing applications has been exploited worldwide in recent years. The present talk aims at presenting an overview of design and operation of cavitational reactors also focusing on the different areas of applications in the area of chemical processing illustrating some typical case studies.

The initial part of the talk will be devoted to basic concepts of cavitation phenomena and mechanism of observed intensification in different chemical systems. It will be demonstrated that depending on the application in question, it is most important to identify the controlling mechanism and then adjust the design and operating parameters[1] so as to maximize the intensification benefits. Guidelines for the optimum design and operating parameters will also be presented. Different designs of cavitational reactors including sonochemical and hydrodynamic cavitation reactors will be discussed and comparison will be presented using two criteria of energy efficiency and cavitational yield estimations for different applications based on the work done by the research group. Some discussion on the commercial applications harnessed successfully will also be presented highlighting the obtained benefits and recommendations for large scale reactors. A successful commercial installation applied for treatment and recycle of frac water in oil and gas explorations will be discussed. The reactor is based on the combined usage of hydrodynamic cavitation, ultrasound and ozone giving synergistic results and has been successfully used for processing of the recycled fluids at commercial sites on over 1200 oil and natural gas wells during hydraulic operations[2].

The talk will also present some experimental case studies using industrially important operations such as crystallization and wastewater treatment highlighting the degree of intensification achieved as compared to the conventional approaches. Possible benefits for the use of ultrasound in crystallization will be highlighted. One specific study related to industrial wastewater treatment[3] based on real effluent from specialty chemical manufacturing unit will be discussed in details. In the work, the effluent treatment was based on the application of hydrodynamic cavitation alone and in combined operation with other oxidation processes focusing on the main objective of a COD reduction. The pretreatment of HC+Fenton process followed by conventional biological oxidation resulted in COD reduction of about 98% (final COD ≤ 250 mg/L), which meets the discharge water compliance. Overall it appears that considerable economic savings is possible by means of harnessing the spectacular effects of cavitation in chemical and physical processing.

Keywords

Reactor Designs; Operating parameters; Chemical processing; Process intensification; Scale up

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Acknowledgements

Authors would like to acknowledge the funding of Department of Science and Technology, India, University Grants Commission India and Mangalam Organics Limited, India for some of the research work demonstrated in this talk.

PL 7 - Jan D'hooge

PL 8 - Truncated Correlation Photoacoustic Coherence Tomography: A New Axial Resolution Enhancement Imaging Modality

Andreas Mandelis[a,b] , Alireza Jangjoo[a,c], Bahman Lashkari[a,b], Koneswaran Sivagurunathan[a,b], Mohammad Reza Baezzat [c]

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[b] Institute for Advanced Non-Destructive and Non-Invasive Diagnostic Technologies (IANDIT), 5 King's College Road, Toronto, ON, M5S 3G8, CANADA

[c] Department of Chemistry, Payame Noor University, P. O. Box 19395-3697 Tehran, Iran

Abstract

In this report I will present a novel photoacoustic (PA) modality using pulsed chirp excitation at a fixed wavelength and spectral analysis based on frequency-domain (FD) processing. Truncated Correlation Photoacoustic Coherence Tomography (TC-PACT) was introduced, a PA axial resolution enhancement methodology, with an application to closely stacked subsurface multilayers of plexiglass coated with a thin layer of graphite acting as surface absorber. The experimental results demonstrated that the signal-to-noise ratio (SNR) and the axial resolution were higher in TC-PACT than in conventional frequency domain photoacoustic. A ns pulsed laser was also used as PA excitation source with axial resolution results found to be commensurate with TC-PACT. However, when the separation distance between adjacent absorbers approached the axial resolution limit of the transducer, the distance was only resolved in TC-PACT compared to pulsed laser PA owing to the lower TC-PACT uncertainty involved in determining the location of the absorbers. The implications of the new modality will be briefly discussed in the presentation.

Keynote Lectures

KN 1 - Glen Harris

KN 2 - The prospective of ultrasound for food processing: Its contribution to sustainable development goals (SDGs) in terms of energy consumption and resource efficiency

Dr. Mohsen Gavahian, Assistant Professor, Department of Food Science, National Pingtung University of Science and Technology, Taiwan

Abstract

Food processing technologies are continuously modified to meet the dynamic demands of society. Nowadays, innovations are needed to overcome the shortcomings of conventional methods such as high energy consumption and quality deterioration. In this sense, emerging processing technologies, such as ultrasound, may help with addressing these issues. Such an approach can also enhance resource efficiency and help with sustainable food consumption which is among the sustainable development goals (SDGs). This presentation aims to elaborate on the advantages, limitations, and prospects of ultrasound technology for food processing will be discussed.

KN 3 - Mikhail Skliar

KN 4 - Targeted treatment of micro-vascularization by imaging-guided photo-mediated ultrasound therapy

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[2]Department of Ophthalmology & Visual Sciences, University of Michigan, Ann Arbor, MI, USA

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Abstract

Purpose: Neovascularization occurs in eye diseases such as diabetic retinopathy and macular degeneration. To achieve improvement management of these eye diseases, we developed an image-guided photo-mediated ultrasound therapy (PUT) technique which concurrently applies nanosecond laser pulses and millisecond ultrasound bursts to precisely and safely remove microvessels in the eye.

Method: Via the studies on the chicken embryo and rabbit eye models, the efficacy and the safety of PUT, as a novel anti-vascular technique, were validated. In parallel, we developed an integrated multi-modality imaging system combining photoacoustic microscopy (PAM), optical coherence tomography (OCT), and fluorescence microscopy (FM) for evaluating the neoangiogenesis in the eye. In this work, by combining the multi-modality imaging and the PUT, image-guided treatment of neoangiogenic vessels in the eye including choroidal, retinal, and corneal vasculatures were explored using the clinically relevant rabbit eye models.

Results: The image-guided PUT can precisely and efficiently remove choroidal vasculature by using safe ultrasound pressure and safe laser fluence. After a single treatment, the elimination of choroidal vasculature can sustain up to 4 weeks. The excellent safety was confirmed by histopathological analyses. The elimination of vessels in the treatment region was confirmed by fundus camera and fluorescence angiogram. PAM, by presenting much more vascular details with extremely high image quality, facilitates treatment monitoring and assessment in real time. In addition, during PUT, cavitation signals were observed by OCT, suggesting that OCT, with good sensitivity in detection microbubbles, can be another imaging modality for online monitoring and guidance of PUT.

Conclusion: Image-guided PUT holds promise as a novel, non-invasive method for treating eye neovascularization. With the guidance from the advanced multi-modality imaging, targeted treatment of microvessels in retina, choroidal, or corneal can be achieved with further enhanced safety and further improved efficacy, which is crucial for realizing personalized treatment with optimal outcome.

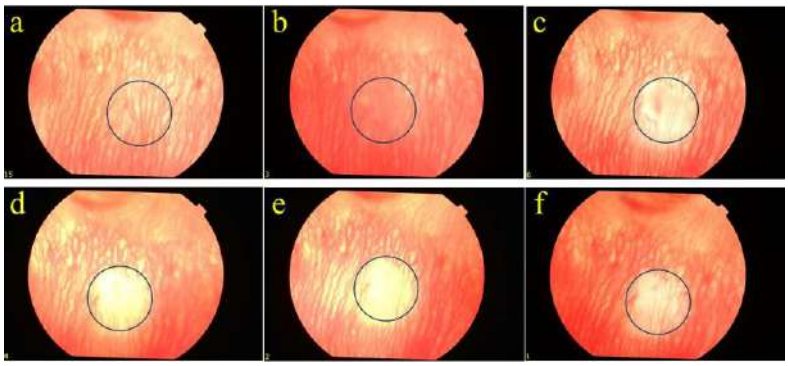

Figure 1. Fundus photographs following a single PUT treatment on a rabbit choroid up to 4 weeks after the treatment. Blue circles indicate the treated area. (a) The fundus photo taken before the PUT treatment. (b) The fundus photo taken immediately after the PUT treatment. The blood vessel margins in the treated area appeared blurry. (c) The fundus photo taken at 1 week after the PUT treatment. Pallor occurred in the region of treatment with largely diminished choroidal vessels. (d), (e), and (f) The photos taken at 2, 3, and 4 weeks, respectively, after the PUT treatment.

KN 5 - Hubert H Lim

KPRK Talks

KPRK 1 - Machin Learning for Improving Ultrasound-guided Interventional Cancer Procedures

Aaron Fenster[1], Nathan Orlando[1], Derek Gillies[1], Jessica Rodgers[1]

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Abstract

Our laboratory has been developing 3D ultrasound imaging instrumentation that can be used for a variety of interventional applications. Our approach is to use a motorized fixture to translate, tilt, or rotate the ultrasound transducer with predefined user-controlled spatial and angular spacing. Any manufacturer's ultrasound transducer can be housed in the fixture and images from the ultrasound machine are acquired into a computer via a digital frame grabber. The acquired images are reconstructed into a 3D image as the images are acquired during a 6-10 sec scan. A key factor in making the procedures efficient is to integrate deep learning tools to perform various analysis tasks automatically and almost in real-time. We have developed a variety of these tools and report on two of these.

Prostate segmentation: Needle-based procedures for diagnosing and treating prostate cancer, such as biopsy and brachytherapy, incorporate three 3D transrectal ultrasound (TRUS) imaging to improve needle guidance. Using these images effectively typically requires the physician to manually segment the prostate to define the margins used for accurate registration and targeting. However, manual prostate segmentation is a time-consuming and difficult intraoperative process, often occurring while the patient is under sedation (biopsy) or anesthetic (brachytherapy). We report on the development of a deep learning-based method to segment the prostate in 3D TRUS images from different facilities, using multiple acquisition methods to create a generalizable algorithm for use in needle-based prostate cancer procedures.

Needle segmentation: Purpose: Many interventional procedures require the precise placement of needles or therapy applicators to correctly achieve planned targets for optimal diagnosis or treatment of cancer. Identifying tools in two-dimensional (2D) images can often be time-consuming with the precise position difficult to distinguish. We report on the development and implemented a deep learning method to segment tools in 2D US images in near real-time for multiple anatomical sites, despite the widely varying appearances across interventional applications.

Keywords

3D ultrasound, deep learning, segmentation

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Acknowledgements

The authors are grateful for the funding support from the Ontario Institute of Cancer Research (OICR), the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Translational Breast Cancer Research Unit (TBCRU).

Oral Presentations

O 01 - Sonochemistry in Aqueous Solutions allows the Formation of Noble Metal NPs on a Nanocarbon and TiN Surfaces

Mohammed Es-Souni,

Institute for Materials & Surface Technology, Kiel, Germany

The sonochemical processing of nanomaterials in a solution is well established and has been advantageously used for a variety of nanomaterials and morphologies thereof. In general, high energy and high frequency ultrasound is applied to a solution containing the ionic species of the elements to be reduced as well as a certain amount of reducing chemicals. For further applications such as catalysis washing, filtering, dispersion and mounting on or mixing in a substrate are necessary. A sonochemical processing of nanomaterials directly on a substrate could make all these steps obsolete. Herein we show that noble metal and nanoalloy nanoparticles (NPs) can directly be processed on nanocarbon and titanium nitride surfaces using a simple ultrasonic laboratory cleaner in aqueous solutions that are free from any reducing chemicals. The process is demonstrated on Au-NPs and nanoalloys of AuPd and PdPt which form a dense distribution on the substrate surface. To illustrate the catalytic activity of the NPs, the electrocatalytic performance of one AuPd-nanoalloy is demonstrated. The results are discussed in terms of reduction phenomena occurring at the interface between the ultrasonic cavitation and the substrate. We think that these reduction phenomena are mediated by the formation of reducing radicals at the substrate surface that are in turn driven by OH radicals from water sonolysis.

O 02 - Driving Molecular Transport across Biological Membranes from Magnetic Nanoparticle/Pulsed Magnetic Field Induced Ultrasound

Viktor Chikan

Department of Chemistry, Kansas State University, Manhattan, KS 66506

There is tremendous interest in developing methodologies to control biological processes at the cellular level remotely. A particularly intriguing concept is to regulate material transport across biologically important membranes by various external magnetic field stimuli converting it to localized sound waves such as ultrasound with the help of magnetic nanoparticles. Since 2007, the Chikan group has been active in magnetic hyperthermia research.[1] Magnetic hyperthermia treatment to eliminate cancer is based on heating cancer cells by applying few milli tesla amplitude alternating magnetic fields in the presence of magnetic nanoparticles inside the cancer tissue. A major concern of the effective use of magnetic hyperthermia is that the amount of heat necessary to eliminate cancer cells and tissues places tight requirements on the effective concentrations of the nanoparticles. Results from our collaborative effort and from others show that magnetic hyperthermia treatment is effective against cancer. As it has been shown the mechanical aspect of moving magnetic particles also contributes significantly to the effectiveness of magnetic hyperthermia treatments. [2] This observation provides a strong rationale for pursuing research on the mechanical aspect of the magnetic nanoparticles and its biological impact in the presence of various magnetic fields types. The Chikan lab has realized early on that to decease the potentially toxic side effects from large quantities of magnetic nanoparticles (few mg of NP/ml of cancer tissue) is to explore the effects of increased magnetic field strengths; therefore, our investigations focused on high magnetic field strengths(Few Tesla) and magnetic field gradients(Few Hundred Tesla/m) for mechanically manipulating magnetic nanoparticles resulting ultrasonic waves.[3]

Discovery of drug Release from magnetic field induced ultrasound from magnetic nanoparticles: In order to understand the behaviors of cell membranes when exposed to short intense magnetic fields in the presence of magnetic nanoparticles, our research has focused on a liposomal model system consisting of phospholipids. The permeability changes in these liposomal drug delivery vehicles modified to incorporate the magnetic NP triggers,[4] which enabled us to make some important discoveries such as: 1) We have successfully demonstrated the ability to prepare liposomes loaded with model drug and triggerable magnetic particles to deliver drugs very rapidly (sub milliseconds), which is great gain over the traditional speed of liposomal drug delivery systems (minutes an hours). 2) The magneto liposomes when triggered with inhomogeneous pulsed magnetic fields release drug molecules. 3) We have discovered that the mechanism of drug release is the result of the ultrasound generation from small magnetic nanoparticles as shown in the Figure 1.[5] 4) The ultrasound is generated from the oscillation of particles (not heat) in the pulsed oscillating inhomogeneous magnetic fields as opposed to the much weaker magnetostriction effect due to homogeneous magnetic fields. Our group utilizing very low duty cycle intense magnetic pulses has achieved comparable drug delivery efficiencies to the results carrier out with magneto liposomes exposed to low amplitude continuous alternating magnetic field studies with 100% duty cycle electro magnets 6) In addition these scientific discoveries, we have developed several

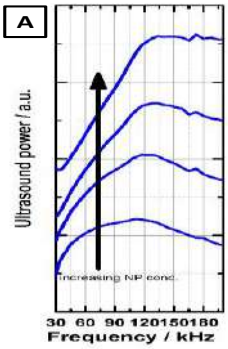
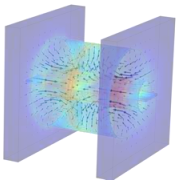


Figure 1 Ultrasound from colloidal iron oxide nanoparticles



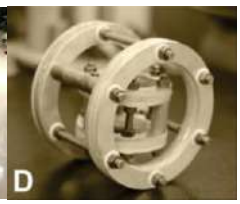


Figure 2 LEFT: COMSOL calculation of Inhomogeneous magnetic field inside anti Helmholtz coil used in cancer therapy. MIDDLE: Portable electromagnet and the integrated power delivery system for cell work. RIGHT: Rotating Pulsed Magnet from Chikan lab

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electromagnets [6] and power delivery system to produce not only homogeneous magnetic fields(~15-20 Tesla), but transient spatially homogeneous rotating magnetic fields (~few hundred milli Tesla) that will be used in the next phase of the proposal. Our newest pulsed magnet and the power delivery system has been integrated on a mobile cart to pursue collaborative studies in cell laboratories. The portable magnet will be replicated to extend collaborations with multiple laboratories simultaneously to increase the impact and applicability of this research and assist other groups to address their specific challenges in relation to induced molecular transport. **Application to Cancer therapy:** As previously stated, microporation induced by inhomogeneous magnetic pulses used in this work have been demonstrated within liposomes. In the next phase of our research, we wanted to explore if the reverse direction of molecular transport (relative to our earlier liposomal work) can be assisted with our approach combining pulsed magnetic fields and magnetic nanoparticles. This microporation technique is applied to facilitate the transport of a model therapeutic agent (doxorubicin) into the U937 cancer cell line.[7] We have shown that the commercially available glucose-coated magnetic nanoparticles accumulated in U937 cell lines prior to application of magnetic pulses and shown no adverse effects on cell viability. Our investigations explored the possibility of increase cell death while concurrently increasing accumulation of doxorubicin via MAFIA (Magnetic (MA) field (F), induced (I), action (A), herein referred to as MAFIA, in which inhomogeneous magnetic fields assisted by magnetic particles with targeting ligands increase drug uptake resulting in selective cell death). We have also demonstrated that other cell lines and drug types also show similar effects.

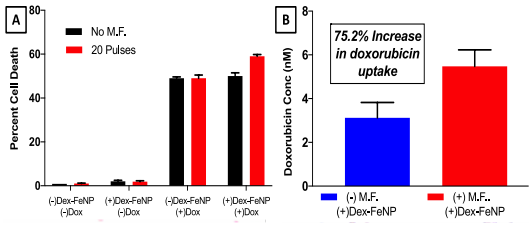

Figure 3 A Percentage of U-937 (human cancer cell line) cell death in combinational treatments in the presence or absence of dextrin-coated nanoparticles, doxorubicin, and or 0, 20, or 50 magnetic pulses applied Quantification via HPLC of doxorubicin uptake within U-937 human cancer cells in the presence of 0.0025 mg/mL of dextrin-coated IONPs, 20 magnetic pulses

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O 03 - Double shelled perfluorocarbon microdroplets as a versatile ultrasound phase-change platform

Damiano Palmieri [1]*, Francesco Brasili[2], Elisabetta Tortorella[1,3], Martina Piermarini[1], Angelico Bedini[4], Gaio Paradossi[1], Fabio Domenici[1]

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[4]INAIL, worker's Compensation Authority, Italy.

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Microdroplets (MDs) with a liquid perfluorocarbon (PFC) core can transform into microbubbles (MBs) when exposed to a proper ultrasound field through the processes known as Acoustic Droplet Vaporisation (ADV) [1]. The properties of the socalled "phase-change" ultrasound contrast agents rely on this process (Figure 1A, C). Thanks to the resonant acoustic response of the MBs formed after vaporisation, MDs can be considered suitable for enhancing the imaging contrast of pathological regions or even for tracking at high frame rate the dynamics in blood flows [2]. Furthermore, MDs may become promising theranostic agents due to their ability to conjugate the dramatically increased ultrasound echogenicity after vaporisation with the drug cargo capability [3]. Significant improvement in this respect mainly passes through the engineering of a shell conferring to the MDs a proper colloidal stability (even upon ADV), chemical versatility and size control [4]. Herein, we present micrometric decafluoropentane (DFP) MDs stabilized by a hybrid shell made up of a double biocompatible layer: the inner one made of dimethyldioctadecylammonium bromide (DDAB) cationic surfactant and an elastomeric external one of crosslinked dextran methacrylate (DexMa) (figure 1B). The high positive charge given by DDAB provides a stability, even to MDs encapsulated by the surfactant monolayer (DDAB MDs) only. It also enables the electrostatic decoration of the MDs with anionic gold nanoparticles (AuNPs), thus unlocking the possibility of optically improving the vaporisation efficiency. The long and saturated hydrocarbon chains of the DDAB shell stabilize the droplet and the drug cargo therein while the DexMa shell allows to obtain stable cavitating MBs upon ADV. Summing up, we obtain a stable and versatile multimodal "phase-change" contrast agent (DDAB+DexMa MDs) which can also act as a drug and/or nanoparticles carrier with several *in vitro* applications.

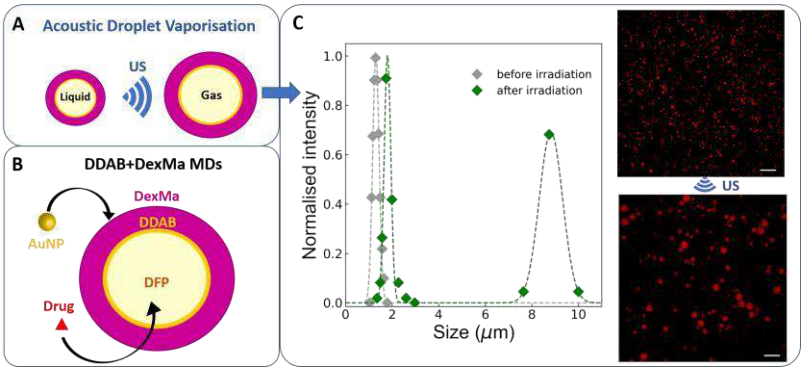

Figure 1. A) Sketch of the ADV process (A), and of versatile DDAB+DexMa MDs (B); dynamic light scattering diameter-intensity distributions and corresponding Gaussian best fits of DDAB+DexMA shelled MDs before (light grey) and after (green) acoustic irradiation and representative confocal laser scanning microscopy micrograph. The ADV process was induced by irradiating MDs for 5 minutes with an acoustic field of 0.5 W/cm^2 intensity at 37 °C. Scale bar is 10 µm.

Keywords

Ultrasound; Microdroplets; Acoustic Droplet Vaporisation; Phase change contrast agents.

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Acknowledgements

This research was realized with the financial support of INAIL under the agreement BRIC2019.

O 04 - Plane Wave Beamforming Based on Adaptive Weighted Frequency Compound

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Abstract

We have studied a method for simultaneous optimization of frequency compound and spatial compound using plane wave transmission and reception [1]. The method that we call FPWC-MVDR (Frequency and Plane Wave Compounding-Minimum Variance Distortionless Response) is an extension of DCR-MVDR (Data Compounded on Receive-MVDR) proposed in [2] as an optimization of plane wave beamforming. In this method, the plane wave transmission direction is set to multiple angles, and transmission with different frequencies is performed several times in each direction. This method enables high resolution imaging in both the range direction and the lateral direction, but the temporal resolution, that is, the frame rate, decreases.

Therefore, in this study, FPWC-MVDR was improved by performing one transmission using the effective band of the probe and extracting multiple frequency subbands from the received echo. In order to confirm that the performance of FPWC-MVDR does not deteriorate even if the multi-frequency transmission is changed to wideband simultaneous transmission and subband extraction, the plane wave transmission is limited to the forward direction. That is, no spatial compound is performed. We evaluate the proposed method by simulation under ideal conditions using the FEM simulator OnScale.

Figure 1 shows that in this simulation a plane wave was transmitted and the entire array composed of 64 elements received the echo. Place the target 18 mm from the transducer in the water-filled area. A chirp with a minimum frequency of 5 MHz and a maximum frequency of 11 MHz was used as the transmission pulse. A wideband chirp is transmitted only once, the received echo is compressed, and then 6 subbands are extracted with a 2 MHz bandwidth whose center frequency is randomly determined. Then, we use such the six chirp signals for beamforming. Figure 2 illustrates the B-mode images of various methods in dB. Figure 2(d) shows the result of using the optimum frequency weighting based on the single transmission proposed this time. On the other hand, the result of FPWC-MVDR which transmitted and received each of the same 6 narrow bands is shown in Fig. 2(c). By comparing the two, even if the narrowband transmission/reception of 6 times was replaced with the wideband transmission/reception of 1 time, no significant difference was seen in the B-mode image.

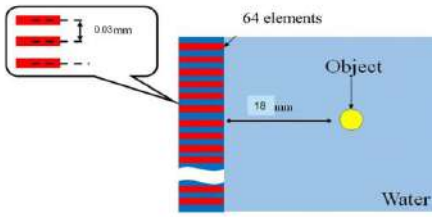

Fig. 1 Experimental setup.

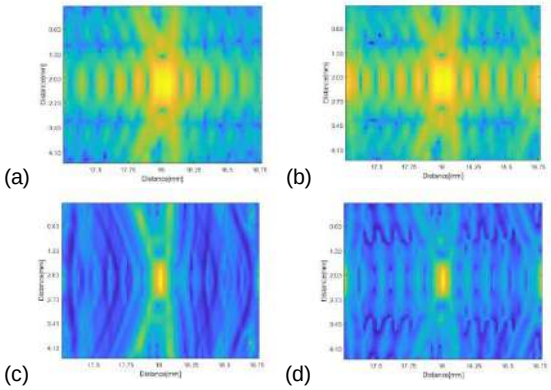

Fig. 2 B-mode images: (a) naive DAS using entire frequencies; (b) integration of 6 narrow bands with constant weight; (c) FPWC-MVDR with 6 transmissions; (d) integration of six narrow bands with optimal weight (proposed method).

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O 05 - High Performance calculation of nonlinear wave propagation on multiple GPUs

Maxim Solovchuk [1,2]*, Manuel Diaz[1], T.W.H. Sheu[2]

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Simulation of nonlinear wave propagation in three dimensional geometry is very time consuming process[1]. In the current work we are going to present three dimensional parallel solver on multiple GPUs. The present solver is based on a conservative hyperbolic formulation derived from a variational analysis of the compressible Navier–Stokes equations and is implemented using an explicit high-order finite difference strategy [2,3]. In this work, a WENO–Z reconstruction scheme along with a high-order finite-difference stencil are used to approximate the contributions of convective and diffusive spatial operators, respectively. Moreover, when compared to an OpenMP implementation running with an i7 processor of 4.2 GHz, this is outperformed by our MPI-GPU implementation by a factor of 99. In this work, the present multi-GPU solver is illustrated with a three-dimensional simulation of a highly-intense focused ultrasound propagation in the presence of shocks. Some examples for the simulation in a patient specific geometry will be also presented[1]. The presented results can be used for the optimization of the treatment.

Keywords

Nonlinear wave propagation, multiple GPUs, Westervelt equation,

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O 06 - Ultrasound and microwave – the advantages and limitation of combined use

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Abstract

Microwave and ultrasound are considered effective methods of process intensification.

The specific effects of microwaves are [1, 2]:

- High speed volumetric heating, because heat exchange with a surface is no longer involved and microwave energy can be transferred directly into the reaction volume - this aspect is very useful in the processing of homogeneous samples;

- Selective heating of the components of a heterogeneous system, when they have different dielectric properties;

The effects of ultrasound are related to the phenomenon of cavitation: the formation, growth and collapse of the cavitation bubbles generated by the passage of ultrasound through a liquid. The cavitational collapse generates radical active species influencing the chemical reactions that take place in the homogeneous environment and which involve an electron transfer [3]. When the environment is heterogeneous, ultrasound effects increase the mass and thermal transfer to the contact surface by asymmetrical collapse of cavitation bubbles [4].

The combined effect of microwave and ultrasound is very visible in heterogeneous environments. In these environments, although microwaves provide rapid heating of the reaction mixture, mass transfer limits the overall speed of the process. On the other hand ultrasound, although capable of greatly increasing mass transfer at the interface, does not ensure sufficient temperature rise to increase the speed of chemical reactions as well [5]. For this reason, the idea of combining the two techniques of process intensification appeared in the literature [6].

The paper presents the main types of equipment that allow the simultaneous use of microwaves and ultrasounds to intensify the processes. There are also presented the types of processes that can be intensified with each of these techniques as well as the restrictions on the combined use of ultrasound and microwave. Also a new combined (hybrid) ultrasonic and microwave installation was described.

Keywords

Ultrasound; Microwave; Combined reactor

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Acknowledgements

The authors acknowledge the financial support received from the PN III, P4: Fundamental and frontier research, Project: „ A new hybrid technology for biorefining: microwaves and ultrasound in one device", financed by contract: PCE 12/2021

O 07 - A numerical model of ultrasonically induced cavitation

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Ultrasonically Induced Cavitation (UIC) consists of the formation of vapour-filled cavities in a liquid medium as a consequence of an applied acoustic field. A vibrating probe, called sonotrode, generates pressure waves by high-frequency oscillations (20 kHz). Those pressure waves control formation, dynamics and eventual collapse of several small vapour bubbles. As a consequence of the bubbles collapse, peculiar thermophysical conditions are induced in the fluid domain like high temperature hot-spots and radicals formation. In the industrial fuel upgrading context, the development of advanced computational fluid dynamics (CFD) models is crucial to optimize geometry and operation parameters of the UIC process. We developed and implemented a new algorithm within the OpenFOAM framework. The approach we adopted uses the Volume of Fluid (VoF) method which was originally proposed by Hirt et al.[1]. The VoF consists of resolving a single transport equation for the volume fraction of either gas or liquid as well as for pressure and velocity. We adopted a diffuse interface approach for the volume fraction transport equation. The bubble dynamics is solved with sub-grid models and the coupling between flow field and micro-scale is performed by introducing appropriate source term in the transport equations. The source terms are decoupled from convective and diffusive components by using the common operator splitting technique. The evolution of the bubble can be decomposed in three steps: nucleation, oscillations and collapse. The oscillations of the bubbles are modelled with the Rayleigh-Plesset equation. In Fig.1 (a) we show the formation of vapour bubbles predicted by the CFD code in a UIC reactor. We also validated the code against experimental results found in the literature [2,3]. Some comparison results are visible in Fig.1 (b, c).

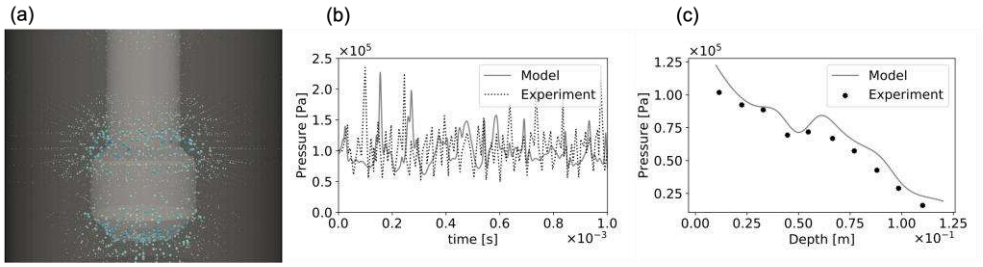

Figure 1: Figure (a) shows the Bubbles distribution in the cavitation zone. Figure (b) reports a comparison of the time-dependent, punctual pressure profile in a UIC reactor. (Znidarcic[4]). Figure (c) reports a space-dependent pressure profile in a UIC reactor (Campos-Pozuelo[5]).

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2Znidarcic et al. *Physics of uids 26.* 023304, 2 (2014).

3Campos-Pozuelo et al. *Ultrasonics sonochemistry 12.* 79{84, 1-2 (2005).

O 08 - Ultrasonic monitoring of fluid substitution processes in porous rocks

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Abstract

During the production of hydrocarbon reservoirs, water flooding or Enhanced Oil Recovery operations, sequestration of CO2 underground or geothermal fluid exchanges at depth, it is well-known that fluid substitution processes can lead to significant changes in rock properties which can be captured by the recording of variations in seismic waves attributes like P- or S-wave velocity, spectral content or attenuation. In the laboratory, such fluid substitution processes can be reproduced on centimeter size rock samples instrumented with piezo-electrical sensors with resonant frequency around 1 MHz, using ultrasonic monitoring techniques.

The motivation of this study was to detect changes in seismic attributes during fluid substitution experiments in reservoir rocks through a direct comparison between the variation in wave amplitude, velocity, spectral content, energy, and the actual fluid distribution in the rocks. Different arrays of ultrasonic P-wave sensors were used to record at constant time steps the waveforms during fluid substitution experiments. Two different experiments are presented:

(i) water injection experiments in oil-saturated sandstone samples under stress mimicking water flooding operations: we found that water weakening triggered mechanical instabilities leading to rock failure. The onset of such instabilities can be followed with ultrasonic monitoring either in the passive mode (acoustic emissions recording) or in the active mode (P wave velocity survey).

(ii) water injection experiments in dry chalk samples showing a relaxation transition during increasing saturation which can be modelled through viscoelastic models. It is also shown that the amplitude of the first P-wave arrival is impacted by the upward moving fluid front before the P-wave velocity is.

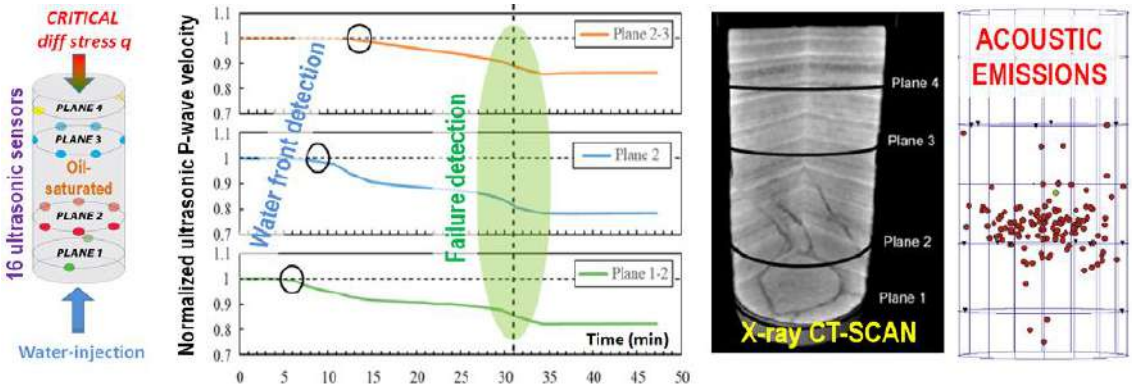

Figure 1. *Water injection experiment into an oil-saturated sandstone sample with active and passive ultrasonic monitoring using an array of 16 ultrasonic P-wave sensors*

Keywords: porous media; ultrasonic sensors; elastic waves; acoustic emissions; fluid substitution

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O 09 - Ultrasonic Enhancement of Convective Heat Transport

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Abstract

Almost every food product is dried during its processing. Drying extends storage life, facilitates handling and transportation. Drying influences also quality of final product. It causes change of colour, flavour and nutritional values of food. Due to the quality of the product the low temperature drying is recommended. Unfortunately the low temperature convective drying is energetically inefficient. Therefore, there are sought new methods to improve the process without raising the temperature. One of these methods is the use of high-intensity ultrasound (US) [1].

According to literature [1] ultrasound enhances moisture transport inside of the material to be dried as well as heat and moisture transfer between the material surface and the surrounding drying medium. It is also obvious that ultrasounds transmit their energy to the dried material. But the heating effect was usually weak or even not observed. An increase in the heat and mass transfer coefficients due to ultrasonic application is widely reported, but only Bantle and Hanssler [2] experimentally studied the influence of ultrasounds on the heat transfer coefficient. They obtained that the ultrasounds caused an increase of this coefficient in the case of heating and a small decrease during cooling.

The aim of the present work is to study an influence of ultrasound on both the heat transfer as well as the heating effect. Mass transfer is not studied. That's why all tested samples are made of steel. Four samples were used: small cylinder, cylinder, cube and cuboid. The samples were heated convectively inside of hybrid dryer (air temperature 41 and 62°C). The heat transfer was enhanced by ultrasound (US power 0, 100, 200 W). Experiments conditions ensured small Biot number regime of heat transfer (the conduction resistance is negligible). The results confirmed both the acceleration of heat transfer and US energy absorption.

Solution of the convective heat transfer together with heat source describing US absorption (small Biot number regime) was used to determine the heat transfer coefficients as well as the power of absorbed energy. The results show that for all the samples an enhancement of heat transfer was obtained. The thermal effect was also observed. The temperature increase was in the range of 5 – 8 degrees. However, in agreement to the literature, only a small percentage of energy was absorbed (0.37 – 1.24).

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Acknowledgements

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I would like to thank my students M. Wielgus and M. Steike for their help in carrying out the research.

O 10 - The role of acoustic coupling in scattering contrast based GHz atomic force microscopy

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Abstract

A number of methods to detect subsurface cracks or defects are being researched. One of these techniques is scattering contrast based GHz atomic force microscopy. In this method modulated elastic waves at GHz frequencies are transmitted through the bottom of a sample. The waves are scattered by subsurface features and travel upwards towards the sample surface. At the sample surface they are detected by an atomic force microscope (AFM) cantilever. The non-linear cantilever tip-sample interaction downmixes some of the energy at the GHz frequency to the modulation frequency (O(100) kHz). The latter is typically chosen to be close to the fundamental cantilever resonance frequency. It is paramount for this technique to ensure a stable and efficient acoustical coupling between the sample and transducer, such that sufficient acoustical energy reaches the surface of the sample. The narrowband nature of the modulated GHz excitation implies a complex wavefield characterized by standing waves. This, combined with the high attenuation at GHz frequencies of liquid coupling layers leads to a requirement on the coupling layer stability and thickness in the order of nano- and micrometer order, respectively. In this work, the modeling and design of a clamp and the associated acoustical measurement method required to monitor and control the coupling layer thickness with nanometer accuracy is presented. Transducers with frequencies between 1 and 3.5 GHz transmitted modulated elastic waves through a sample (typical size 10x10x1 mm^3). An AFM was used to read-out the out-of-plane sample surface displacement. Water was used as a coupling medium. The capillary effect combined with a specially designed basin was used to counteract evaporation. The Krimholtz, Leedom, Matthae (KLM) model was used to model the acoustical behavior the piezo transducer, delay line, coupling layer and sample. Its thickness was controlled with a custom designed clamp using real-time pulse-echo measurements combined with custom signal processing based on detecting the acoustic resonances of the transducer – coupling layer – sample stack. Figure 1 details the out-of-plane sample surface displacement versus the carrier frequency as a function of the coupling layer thickness. The peak derivative was 3 dB/nm, thus a 2 nm coupling layer thickness stability was needed to obtain the sufficiently stable standing wave pattern for good quality AFM measurements. The measurements indicated that the clamp allowed for stable coupling layers (<1 µm in thickness with variations <2 nm / 10 mn) and successful scattering based GHz AFM measurements over periods of hours.

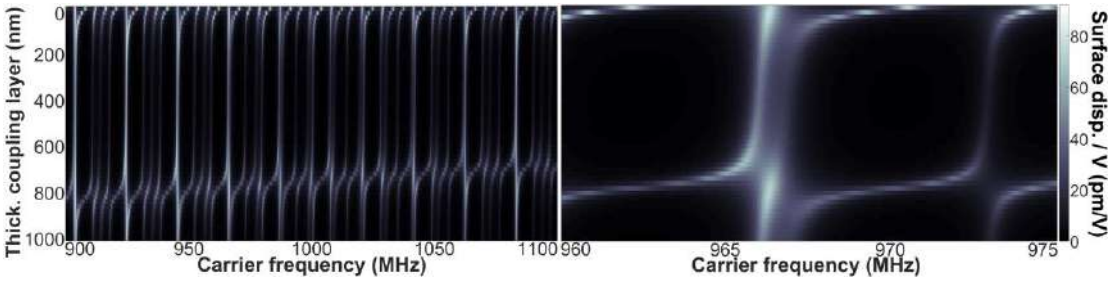

Figure 1. *simulated out-of-plane top sample surface displacement/excitation Voltage vs coupling layer thickness and carrier frequency.*

Keywords: atomic force microscopy, metrology, viscoelasticity, ultrasound, scattering

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O 11 - All-Optical Ultrasound Imaging for Minimally Invasive Surgery

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Abstract

All-optical ultrasound imaging has made rapid progress as a technique for medical imaging, moving from the benchtop to *in vivo* studies. With this technique, ultrasound is generated and received using light, enabling wide bandwidths, high sensitivity, and device miniaturization. These properties make it well suited to minimally invasive procedures. Using two optical fibres, one for ultrasound transmission and a second for ultrasound reception, a series of devices can be fabricated. Here we discuss a series of devices we have pioneered with this technology, including real-time M-mode imaging, side-viewing intravascular imaging, and imaging in combination with robotic control.

In these devices, ultrasound generation occurs via the photoacoustic effect, with pulsed excitation light delivered to an optically absorbing coating on the end of an optical fibre. By applying this coating to the cleaved end surface of an optical fibre, ultrasound can be generated co-linear with the fibre axis. Using such a device we have demonstrated forward-viewing real-time M-mode imaging *in vivo* [1] and of a dynamic heart phantom (Figure 1.a). Alternatively, by redirecting light from the optical fibre to a side surface, ultrasound can be transmitted perpendicular to the fibre axis. Rotating the ultrasound beam then facilitates the acquisition of a 2D image. Using this method, we acquired rotational images with a depth resolution < 40 µm and an angular resolution *ca.* 14° (Figure 1.b) [2]. We will present these innovations and more, including a combination of forward-viewing all-optical ultrasound imaging and robotics, enabling wide area 3D image scans (Figure 1.c) [3], and the potential for freehand 3D imaging.

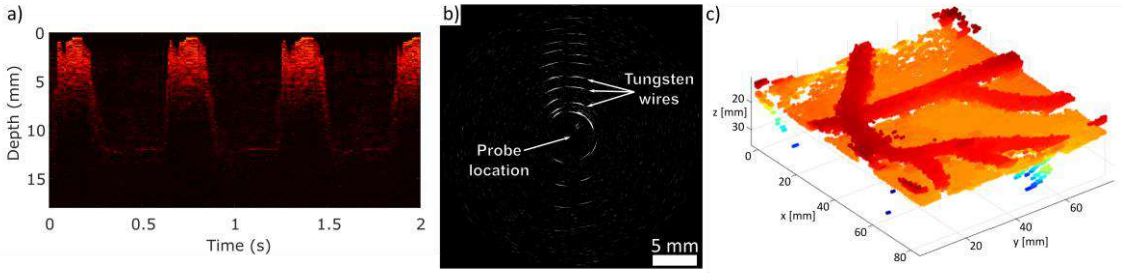

Figure 1. All-optical ultrasound images. a) Real-time M-mode image of a heart valve phantom. b) Rotational image of a tungsten wire resolution phantom. c) Large area robot assisted 3D image of a tissue mimicking placenta phantom.

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Acknowledgements

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O 12 - Ultrasound Imaging with a Multimode Waveguide using a Time Reversal Virtual Array

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Abstract

The resource efficiency of many relevant industrial processes, such as aluminium electrolysis, strongly depends on the interaction of melts and liquid-solid interfaces. In order to control and optimize those processes, in situ imaging of interfaces in hot, opaque liquids is required. However, ultrasound-based imaging methods are severely limited by the temperature resistance of the transducers. We propose a novel method for imaging in hot liquids using an ultrasound phased-array probe attached to a multi-mode waveguide (MMWG) for thermal decoupling. The complex sound propagation through the MMWG, which leads to a strongly distorted image, is compensated with a time reversal virtual array (TRVA) [1]. The TRVA method exploits the time invariance of the wave equation in linear media to focus on a set of calibrated points. These are combined to form a virtual array on the distal end of a waveguide and allow focusing into the measurement volume. In this contribution, we validate the TRVA principle numerically and experimentally using a generic ultrasound research platform, the phased array Doppler velocimeter (PAUDV) [2]. We characterize the imaging properties in liquid tin at 300 °C and demonstrate planar imaging of inside the region of interest (Figure 1). The proposed method paves the way for in-process imaging of industrial processes involving hot liquids.

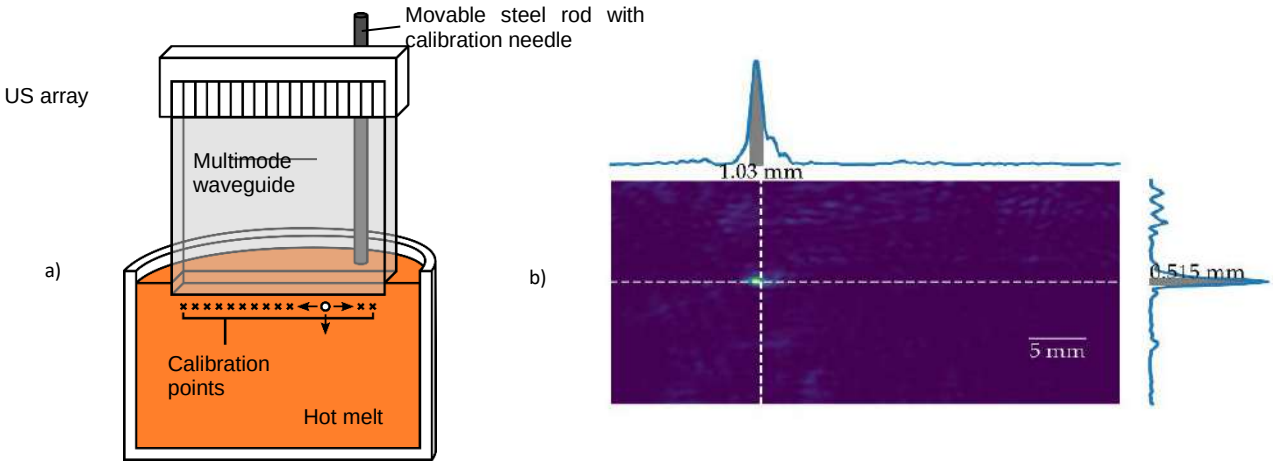

Figure 1. *a) Experimental setup for in situ imaging of an interface in liquid tin at 300 °C through a multimode waveguide. b) Point spread function in liquid thin at 300 °C obtained from a single scatterer at (-9 mm, 15 mm) after correction with the TRVA. The ultrasound frequency is 3 MHz.*

Keywords

time reversal, multi-mode waveguide, adaptive imaging, ultrasound

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Acknowledgements

The authors like to thank Arne Klaß for his help conducting the experiment. This research was funded by Deutsche Forschungsgemeinschaft, grant number Cz 55/43-1.

O 13 - Ultrasonic properties and texture of plant-based meat analogues

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Abstract

Plant-based meat analogues are progressively gaining a lot of interest in the food industry as healthy and sustainable alternatives to meat consumption. However, obtaining the most appealing meat structure and texture from plant proteins is challenging. The most common way of producing texturized plant-based products is by extrusion. The characteristic textural features of meat analogues depend on the alignment of proteins in the extruding die, on the extrusion conditions such as barrel temperature and screw speed, and ingredient properties. Accordingly, development of desired textures in plant-based meat analogues is a complex process that needs to be fully understood and monitored [1,2]. To tackle this challenge, extrudates from a blend of soy protein isolate, soy protein concentrate and wheat gluten have been produced, using a twin-screw extruder and different extrusion conditions [3]. The ultrasonic properties (phase velocity and attenuation) of the extrudates have been assessed using an ultrasonic air-coupled system (200kHz - 600kHz) placed at the output of the die during production, or later in the lab after production [4]. Texture measurements were also performed on the same products with a texture profile analyzer to acquire information on the level of texturization [2], which is a good signature of the formation of meat-muscle-like fibers in an extrudate. The correlation between extrudate texture and ultrasonic properties was then determined in order to assess the feasibility of using ultrasound to quantify the textural quality of the product during production.

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O 14 - Platelet-rich plasma versus Tenex in the treatment of medial and lateral epicondylitis

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Abstract

Background: Medial epicondylitis and lateral epicondylitis are among the most common elbow pathologies affecting people aged between 40 and 50 years. Although epicondylitis is often a self-limiting condition that improves with conservative treatment, the condition can be difficult to eradicate. The purpose of this study was to compare the effectiveness of platelet-rich plasma (PRP) injections and ultrasound-guided percutaneous tenotomy (Tenex) for the treatment of medial or lateral epicondylitis. Our hypothesis was that the Tenex procedure would not be inferior to PRP injections in the treatment of medial or lateral epicondylitis. Methods: In this retrospective review, 62 of 75 patients were available for contact via phone and e-mail to complete post-procedure patient-reported outcome surveys. Subjective assessment of pain and function included a visual analog scale for pain; the Quick Disabilities of the Arm, Shoulder and Hand questionnaire; and the EuroQol-5D questionnaire. The inclusion criteria included age of 18 years or older and previous failure of nonoperative treatment. Results: The average ages in the PRP and Tenex groups were 47 years and 51 years, respectively. The PRP cohort (n = 32) included 10 female and 22 male patients, whereas the Tenex cohort (n = 30) included 12 female and 18 male patients. The PRP and Tenex groups both demonstrated clinical and statistical improvement in visual analog scale pain scores; Quick Disabilities of the Arm, Shoulder and Hand scores; and EuroQol-5D scores. No statistically significant difference was found between the 2 treatment modalities. Conclusion: The PRP and Tenex procedures were both successful in producing clinically and statistically significant improvements in pain, function, and quality of life.

Keywords: Elbow pain; Tenex; epicondylitis; golfer's elbow; platelet-rich plasma; tennis elbow.

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Biostatistics and Bioinformatics for their help with drafting and implementing the repeated-measures analysis plan for the study outcomes

O 15 - Sonosensitized ROS generation using peroxide compound: Kinetic aspects and its possible applications for SDT treatments.

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Abstract

The thermal decomposition of 9,10 diphenylanthracene peroxide (DPAO2) generates DPA and a mix of triplet and singlet molecular oxygen. The thermal efficiency to produce singlet molecular oxygen is 0.35 [1]. On the other hand, ultrasound irradiation (US) can create hydrodynamic stress (sonomechanical process), inertial cavitation (pyrolitic process) and long range effects mediated by radicals or ROS [2]. Even when sonolysis of pure water can yield hydrogen or hydroxyl radicals and hydrogen peroxide (ROS) we are more interested on the sonosensitization processes. In spite of large amount of reported results in literature, the term sonosensitizer and the sonosensitization process are not well defined. We define sonosensitized reaction as one in which a chemical species decompose as consequence of cavitations phenomena producing ROS or other radicals and some other target species does undergo a chemical reaction.

When DPAO2 (Sonosensitizer) in 1,4 dioxane solution is irradiated with 20 or 24 kHz, the production of singlet molecular oxygen is observed. Specific scavengers like tetracyclone (TC) are used to demonstrate it. The efficiency now is 0,85 showing that the sonochemical process is much more efficient that the thermal one [3]. Considering that the sonoreaction is directly related to the collapse of the cavitation bubbles within the solvent, we studied the effect of the variation of the acoustic power on the specific rate constants of the DPAO2 decomposition.

Thus we have transformed the classic expression of Arrehnius to:

ln k = ln A - {Ea Pv / R To (K-1)} 1 / Pa

Even when the terms have their classic meanings, T is interpreted as relative to the maximum temperature reached in the bubble at the time of its collapse, now being expressed in terms of the acoustic pressure (Pa) applied. The series of experiences that were carried out by varying the processor power between 4 Watts and 18 Watts, observing a direct dependence of the natural logarithm of the specific speed counter with the inverse of the acoustic power as predicted by equation. Collapse temperature as high as 4000 K is estimated which corresponds perfectly with the process studied. The activation energies found by this methodology are consistent with literature data for the phenomenon of thermal decomposition.

The effect of US on peroxide compounds was not adequately studied, and then we have explored the behavior of some natural and synthetic compounds like peroxy ketones and artemisinin between others. We present a general method to establish the relative efficiency of different sonosensitizers which produce the same ROS for SDT (sonodinamyc treatment of cancer). To demonstrate it, we use peroxides as sonosensitizers which produces singlet molecular oxygen. The method is easily generalized by all types of ROS.

Keywords: SDT; Singlet Oxygen; Peroxides

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O 16 - Parametric Speakers: Between Art and Scientific Research

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Abstract

In this presentation, I will go through three recently published articles that stemmed from a 2-year research with parametric loudspeakers. Although the main goal was creating artistic works with this technology, the project also included a scientific study to characterize said speakers. After presenting two sound installations that use directional ultrasonic sound in different ways, I will ultimately focus on the disassembling of a parametric speaker in order to explore what steps in the DSP, at the conditioning stage of an input signal, have the greatest effect on self-demodulation. By means of statistical Design of Experiments, empirical mathematical models that account for response variables such as the total harmonic distortion and the perceived intensity of the fundamental tone were finally elaborated. [3].

Keywords

Parametric speakers; Sound installations; Design of Experiment; Digital Signal Processing; Soundlazer

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O 17 - Assessment of Fracture Risk in Elderly using Bi-Directional Axial Transmission: First Results in Clinical Environment

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Abstract Accurate measurement of cortical bone parameters may improve fracture risk assessment and help clinicians on the best treatment strategy [1]. The objective of this cross-sectional study was to evaluate the performance of a Bi-Directional Axial Transmission (BDAT) device used by trained operators in a clinical environment with elderly subjects. The device, positioned at one-third distal radius, provides two velocities: VFAS (first arriving signal) and VA0 (first anti-symmetrical guided mode) [2]. Moreover, two parameters are obtained from an inverse approach: Ct.Th (cortical thickness) and Ct.Po (cortical porosity) [3]. The areal bone mineral density (aBMD) was obtained using DXA at the femur and spine. Eighty seven (65 women, 22 men) from Marien Hospital and St. Anna Hospital (Herne, Germany) were included in this study. Age ranged from 41 to 95 years, while body mass index (BMI) ranged from 17 to 47 $kg.m^{-2}$. Three groups were considered: 64 non-fractured patients (NF 73±13years), 23 with non-traumatic fractures (F 80±10years) including 13 patients with non-vertebral fractures (NVF 85±7years).. VFAS, VA0 and CT.po could discriminate the subgroup NVF from the control group NF (Wilcoxon–Mann–Whitney test $p<0.05$), while discrimination was observed only for VFAS for the group F. We found the ratio CtPo/Ct.Th to be predictive for the fracture, after sex, BMI and age adjustment, comparable to femoral aBMD (Table 1). The fracture risk assessment by BDAT method in elderly, in a clinical setting, suggests the benefit of the affordable and transportable device for the routine use.

Table 1. Odds ratios (OR) and areas under the ROC curve (AUC)

	all non-traumatic fractures F (N = 23)			Non vertebral fractures NVF (N = 13)		
	AUC [95% CI]	OR [95% CI]	*p*	AUC [95% CI]	OR [95% CI]	*p*
ajusted parameters						
Ct.Th	0.66 [0.53 - 0.78]	1.22 [0.71 - 2.10]	0.470	0.77 [0.60 - 0.86]	1.13 [0.56 - 2.30]	0.731
Ct.Po	0.67 [0.56 - 0.81]	1.21 [0.70 - 2.07]	0.490	0.81 [0.72 - 0.92]	1.75 [0.84 - 3.65]	0.125
VFAS	0.68 [0.55 - 0.81]	1.66 [0.90 - 3.08]	0.101	0.77 [0.62 - 0.88]	1.39 [0.61 - 3.14]	0.421
VA0	0.65 [0.53 - 0.77]	1.18 [0.60 - 2.31]	0.623	0.77 [0.60 - 0.85]	1.69 [0.64 - 4.50]	0.282
BMD tot	0.74 [0.58 - 0.83]	2.88 [1.31 - 6.32]**	**0.007**	0.81 [0.64 - 0.92]	3.33 [1.10 - 10.04]*	**0.029**
BMD fn	0.74 [0.62 - 0.85]	2.64 [1.21 - 5.77]*	**0.013**	0.82 [0.71 - 0.91]	3.48 [1.11 - 10.91]*	**0.029**
BMD spine	0.69 [0.54 - 0.80]	1.72 [0.87 - 3.42]	0.111	0.78 [0.65 - 0.87]	1.62 [0.64 - 4.07]	0.296
adjusted combination of ultrasonic parameters						
Ct.Po / Ct.Th	0.68 [0.54 - 0.79]	1.52 [0.81 - 2.85]	0.186	0.83 [0.71 - 0.91]	2.62 [1.02 - 6.75]*	**0.042**
Ct.Th	0.69 [0.55 - 0.81]	1.50 [0.78 - 2.88]	0.218	0.83 [0.73 - 0.92]	2.33 [0.81 - 6.72]	0.112
Ct.Po		1.49 [0.77 - 2.85]	0.224		3.04 [1.04 - 8.92]*	**0.038**

Reference category is non fractured (NF) $N = 64$. CI confidence interval. ROC receiver operating characteristic AUC and OR are adjusted for age, BMI and sex. *p < 0.05. **p < 0.01. ***p < 0.001

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O 18 - Use of 2D transvaginal ultrasonography and hysterosalpingo-foam sonography for assessment of the efficacy of Essure hysteroscopic sterilization

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Abstract

After Essure (Bayer AG, Leverkusen, Germany) hysteroscopic sterilization procedure, a confirmation test is performed to evaluate the micro-insert position or tubal occlusion and assess the success of sterilization [1]. The imaging techniques used for ascertaining the correct microinsert position or tubal occlusion may vary among countries and include hysterosalpingography (HSG), sonography, plain pelvic radiography, and hysterosonography [2, 3]. However, HSG remains reference standard [4]. Non-HSG techniques are preferred because HSG is an invasive procedure that exposes the patient to ionizing radiation, is uncomfortable for the patient, and can be associated with adverse effects. Recently, hysterosalpingo-foam sonography (HyFoSy) was introduced and was suggested to be a possible less invasive alternative to HSG [5]. Our prospective study included patients, who underwent Essure hysteroscopic sterilization, followed by 2D transvaginal ultrasonography, HyFoSy and HSG 12 weeks after sterilization. The purpose of our study was to evaluate the accuracy of 2D tranvaginal ultrasonography and HyFoSy compared to HSG for assessment of the efficacy of Essure hysteroscopic sterilization.

Keywords

transvaginal ultrasonography; hysterosalpingo-foam sonography; hysterosalpingography; hysteroscopic sterilization

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O 19 - Compressed Ultrasound Signal Reconstruction Using a Low-Rank and Joint-Sparse Representation Model

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With the introduction of very dense sensor arrays in ultrasound imaging, data transfer rate and data storage can become a bottleneck in ultrasound system design. To reduce the amount of sampled channel data, we propose a new approach based on the low-rank and joint-sparse model that allows us to exploit the correlations between different ultrasound channels and transmissions. With this method, the minimum number of measurements at each channel can be lower than the sparsity in compressive sensing theory. The accuracy of the reconstruction is less dependent on the sparse basis. An optimization algorithm, based on the simultaneous direction method of multipliers, is proposed to efficiently solve the resulting optimization problem. Results on different datasets with different experimental settings show that the proposed method is better adapted to the ultrasound signals and can recover the image with fewer samples (e.g. 10% of the samples) than the existing CS-based methods, while maintaining reasonable image quality.

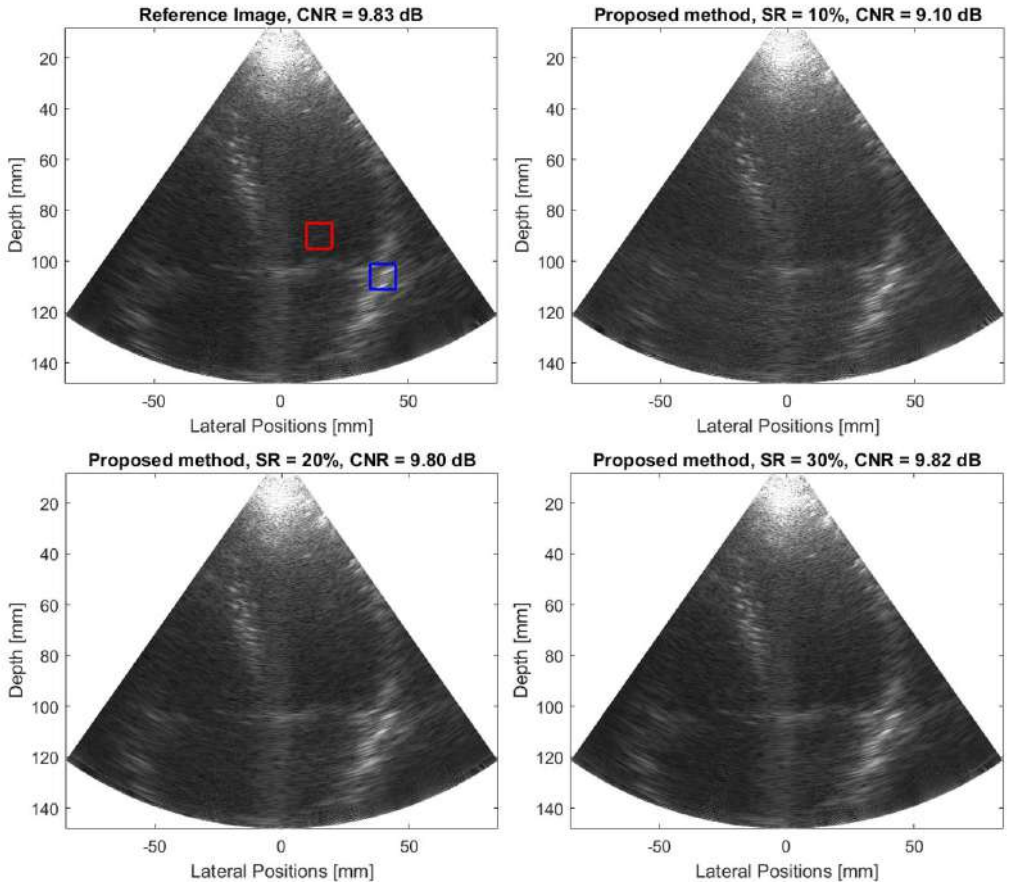

Figure 1. Original in vivo cardiac image and the images reconstructed by the proposed method with different sampling rates. The red and blue block in the reference image represent the regions used to compute CNR.

Keywords

Compressive sensing; Matrix completion; Low-rank and Joint-sparse model; Ultrasound Imagin

O 20 - Ultrasound Stimulation of Insulin Release from Pancreatic Beta Cells as a Potential Novel Treatment for Type 2 Diabetes

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Type 2 diabetes mellitus (T2DM) is a complex metabolic disease that has reached epidemic proportions. Pharmacological management routinely requires complex therapy with multiple medications and loses its effectiveness over time. The aim of this study is to explore a potential new, non-pharmacological strategy that utilizes the non-invasive application of ultrasound to address secretory deficiencies in T2DM patients. Our experiments consisted in assessing the safety, effectiveness and controllability of ultrasound-induced insulin secretion from pancreatic beta cells in models of increasing anatomical and physiological complexity.

The capability of ultrasound to stimulate insulin release from pancreatic beta cells was assessed *in vitro* on INS-1 beta cell line; *ex vivo* on rabbit pancreases; and *in vivo* on a mouse model. Planar ultrasound transducers with center frequencies of 800 kHz – 1 MHz were used to treat these different models for a duration of 5 min and acoustic intensities no higher than 1 W/cm^2. Insulin release produced by ultrasound stimulation was quantified, via ELISA assays, from extracellular substrates at t = 0 min (before treatment), t = 5 min (immediately after treatment) and t = 35 min (30 min after treatment) and compared to levels measured from sham groups. The temporal dynamics and Ca^{2+}-dependency of ultrasound-induced secretions were evaluated *in vitro* through carbon fiber amperometry and experiments on Ca^{2+}-depleted mediums, respectively. The secretory selectivity of the treatment was evaluated *ex vivo* and *in vivo* by measuring levels of released insulin compared to released levels of other pancreatic hormones and enzymes, such as glucagon or alpha amylase, that could be stimulated in parallel as a result of ultrasound treatment. Finally, the immediate tolerance of the treatment was evaluated via cell viability techniques *in vitro* and histological analysis of pancreatic tissue *ex vivo* and *in vivo*.

Our results showed that cell viability and tissue integrity were not significantly affected during and for up to 30 min after treatment when exposed to 800 kHz ultrasound. Cell exposure to 800 kHz ultrasound resulted in significant increase in insulin release *in vitro* ($p < 0.005$), *ex vivo* ($p < 0.05$), and *in vivo* ($p < 0.005$). Ultrasound-triggered insulin secretions *in vitro* were shown to be Ca^{2+}-dependent and to occur so long as the cells are exposed to ultrasound treatment. Ex vivo studies exhibited no significant release of pancreatic enzyme alpha amylase, while both ex vivo and in vivo experimentation confirmed no significant release of glucagon, a peptide hormone with opposite effect to that of insulin in glucose metabolism. These results show that our therapeutic approach may lead to novel strategies in the treatment of diabetes and other secretory diseases.

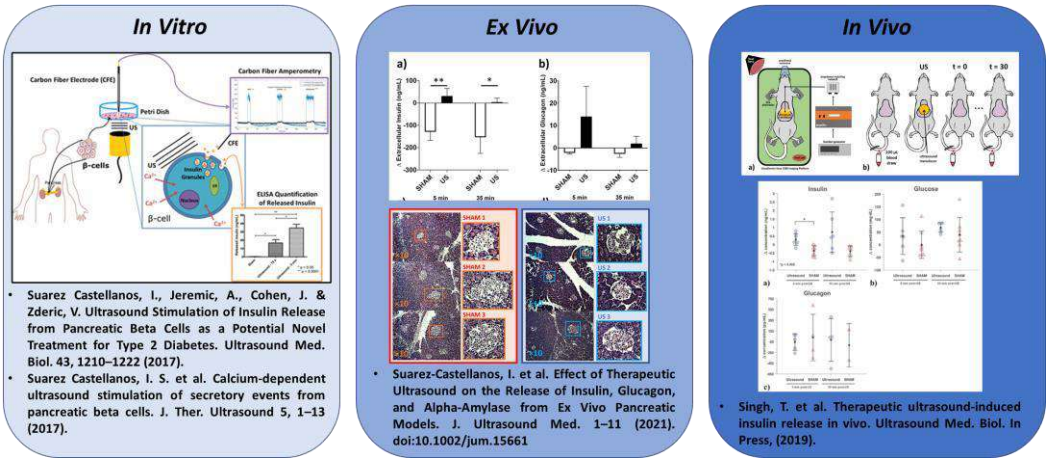

Figure 1. *Results of Ultrasound-Stimulation of Insulin Release from In Vitro, Ex Vivo and In Vivo Pancreatic Models*

Keywords: Therapeutic Ultrasound, Type 2 Diabetes, Insulin Secretion, Beta Cell Stimulation

O 21 - The impact of ultrasound (US) on the development of anesthesia techniques

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Anesthesiology as a medical specialty is a combination of science and art. On one side we possess scientific evidence for almost any drug and technique, our knowledge is based on applied anatomy and physiology, we are clinicians, taking care of our patients in the operating room and outside it, and we also develop various fields of interest, which are beyond the traditional domains of the specialty (pain, preanesthetic clinics, etc).

But in the same time we do not know how exactly our drugs act on the central nervous system, we do not have the exact formula for calculating the drug dosage, and above everything a good part of our techniques are blind, a fact which obliges the anesthesiologist to use anatomical landmarks, sometimes with a lot of difficulties.

Most of the technical problems refer to the performance of logoregional anesthesia. The paradox consists in the fact that this kind of anesthesia has clear advantages over general anesthesia (fewer side effects, quick recovery, postop analgesia), but because of using blind methods its success is sometimes inconsistent, and complications produced by the needle injury or intravascular injection are not rare, the locoregional anesthesia has evident drawbacks.

Here comes the ultrasound (US) technology.

Its main advantage (Perlas A and Chan V, 2007) is "*ability to provide anatomic examination of the area of interest in real time".*

US provides a complete image of the peripheral nerves.

It affords easy identification of the nerves from the adjacent structures. It can follow the oblique course of the nerve and needle and if offers a clear image of the surrounding vascular structures.

But , of course, the use of US is not limited to locoregional anesthesia.

The lecture would deal with the main domains of US use in anesthesia, among them surgical anesthesia of peripheral nerves, management of chronic pain, spinal and epidural anesthesia in obstetrics, diagnosis of lung pathology (such as occult pneumothorax), quantification of the gastric content (in order to prevent aspiration during general anesthesia) and also assessment of airways in case of predicted difficult tracheal intubation.

O 22 - Ovarian cancer cells under ultrasound exposure of doxorubicin show an enhanced immunogenic cell death

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Abstract

Background. Ultrasound (US) is a mechanical wave that can be employed in many different fields. In recent years, the safety and very good tissue penetrating ability of US has prompted to the possibility of employing US-based strategies, not just as diagnostic tool, but also for therapeutic purposes. Therefore, US has been used for various therapeutic approaches such as promoting tissue healing, decreasing chronic pain, tumor ablation and drug release from drug delivery systems but, one of the most attractive approach, remains the sonodynamic therapy (SDT) [1]. SDT is an anticancer and antibacterial approach based on the use of US to activate a chemical compound, called sonosensitizer, through acoustic cavitation enhancing the sonosensitizer cytotoxicity. A chemical compound that can act as sonosensitizer, is doxorubicin, a potent anticancer agent used for the treatment of a huge variety of cancers. In particular it has a key role in the second line treatment of ovarian cancer. However, the overall survival rates of ovarian cancer remain considerably worse than those for other gynecological malignancies mainly because the cancer comes back, or recurs, after treatment in more than 70% of women with the disease. For this reason, many efforts in pharmacological research have been made in order to increase doxorubicin efficacy against ovarian cancer such as inducing immunogenic cell death (ICD) for a long lasting protective antitumor activity [2]. On this point, US-based strategies, as SDT, seems to be highly encouraging. Methods. In this work, we addressed the relapsing issue, proper of ovarian cancer, investigating the increase of doxorubicin-induced ICD through US. In this regard, experiments have been carried out on the human ovarian cancer cell line A2780 to test if the activation of low doxorubicin concentrations by US is effective in maximizing the doxorubicin-induced ICD. Moreover, hypericin, a natural well-known ICD inducer, has been used as yardstick, in comparison to doxorubicin. Results. The activity of doxorubicin and hypericin under US exposure was first investigated on A2780 cell proliferation, observing a statically significant decrease of cell proliferation over time. Along with this, specific biomarkers associated with ICD have been taken into consideration such as the expression of calreticulin (CRT) at the cell surface and the ATP production. US exposure of doxorubicin or hypericin was able to induce a statistically significant increase of ATP production and CRT expression. Finally, the expression of genes involved in the ICD pathway (such as CRT, LC3II and HMGB1) have been analyzed by real time RT-PCR after US exposure of doxorubicin or hypericin. Conclusions. The data obtained showed, for the first time, that the use of US is an efficient strategy to significantly boost doxorubicin-induced ICD, opening new encouraging developments in the treatment of ovarian cancer.

Keywords

Ultrasound (US), immunogenic cell death (ICD), Sonodynamic Therapy (SDT), Doxorubicin

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O 23 - Ultrasound in convective drying of white mushroom

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Abstract

Among all mushroom species, white mushroom is produced on the largest scale. It is popular not only because of its taste and aroma, but also due to the nutritional value. It is a valuable source of B and D group vitamins as well as minerals such as potassium, magnesium, phosphorus, zinc, copper or selenium. White mushrooms are also rich in antioxidant compounds, e.g. phenolic compounds with high antioxidant, anti-inflammatory, antiviral and antibacterial properties [1]. Due to short shelf-life after harvesting the raw mushrooms have to be preserved. One of the most popular method of food preservation is drying. During drying the properties of food products usually change depending on the conditions at which they are processed. In order to improve the drying effectiveness and product quality, and to reduce the energy consumption, modern drying methods are sought [2,3].

In this study, the influence of high power ultrasound on the convective drying (CV) kinetics (drying rate and time), quality of products (colour, water activity, total polyphenol content), and energy consumption was analysed. The experimental data were fitted to a few thin-layer drying models and the effective diffusion coefficient was calculated. White mushrooms were dried by a laboratory-scale hybrid dryer equipped with an air-heating system and high power ultrasound (US). The effects of the ultrasound power (100 and 200 W) were studied at two different air temperatures of air 50°C and 70°C, respectively. The obtained results clearly show that the use of ultrasound had a positive effect on the kinetics and energy consumption of convection drying, regardless of the air temperature. The average drying rates presented in Figure 1 are higher for ultrasound-assisted processes. In the case of drying at 70°C, the increase in drying rate was slightly higher compared to drying at 50°C. Furthermore, the quality assessment showed that the use of hybrid drying (CVUS) is a good alternative to hot-air drying technique.

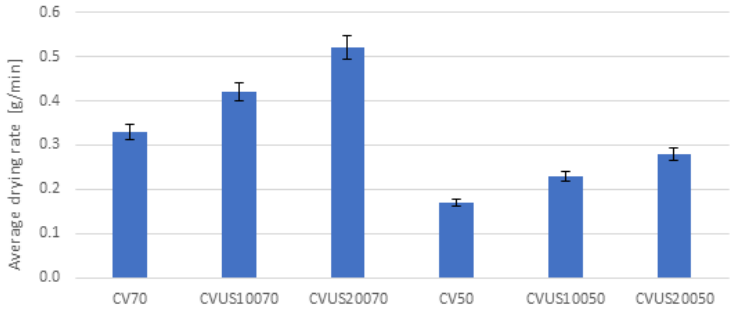

Figure 1. *Average drying rate for each of the drying processes of white mushroom.*

Keywords

Hybrid drying; Air-borne ultrasound; Effective diffusion coefficient; Colour; Polyphenols

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O 24 - The impact of ultrasound pre-treatment on selected properties of dried mushrooms

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Abstract

Drying is one of the most popular food processing methods. It depends on the evaporation of water and thus decreases both water content and water activity. The progress of drying food tissue systems such as fruits and vegetables is mainly limited by the cellular structure of the food. Therefore, the degradation of the cellular structure of food may result in an intensification of drying and modification of dried product quality. Because of its mechanism of action, ultrasound applied prior to drying may enhance drying and improve the quality of dried material [1].

The aim of this work was to analyze the impact of immersive sonication applied prior to drying as carried out by different techniques: convection, microwave and infrared method on kinetics and selected properties of mushrooms. The response surface methodology (RSM) was applied to design the experiment in which sonication time (10-30 min) was one of the variables while the second one depended on the drying method: air temperature (55-85°C) – in the case of convection drying; microwave power (100-300 W) – in the case of microwave drying, the distance from the source of infrared emitter (10-30 cm) – in the case of infrared drying. After drying following properties of mushrooms were analyzed: dry matter content, water activity, colour, hygroscopicity, rehydration, phenolic content and antioxidant activity.

Ultrasound treatment modified the kinetics of drying but the effect depended both on the drying method and processing parameters. For instance, sonication reduced microwave drying time by 10% in comparison to untreated material only for the processes that was carried out at 100 W whereas no effect of sonication was observed for protocols performed at 200 and 300 W. The dry matter content of dried mushrooms varied between 73.9 and 96.4%. However, lower values were usually stated for mushrooms dried by microwave method which together with a higher water activity (0.271-0.701) values reported for products dried by this method limits utilization of this technique as a single treatment, especially when lower power were applied. Mushrooms dried by convection and infrared method exhibited lower values of water activity which did not exceed 0.7. The reconstitution properties of mushrooms depended also on drying method, drying conditions and sonication time. For example, the rehydration ratio of convective dried mushrooms subjected before drying to 10 minutes of sonication was lower than untreated ones for all investigated temperatures. When the sonication lasted 30 minutes the change of rehydration properties was associated with the temperature of drying. Phenolic content of dried mushrooms varied from 6.9 to 16.8 mg CAE/g s.s., 9.4-15.7 mg CAE/g s.s. and 7.6-19.5 mg CAE/g s.s., for convective, microwave and infrared dried material, respectively. The most visible effect of sonication on phenolic content was observed when mushrooms were subjected to microwave drying – all samples dried at 200 and 300 W and subjected to sonication exhibited higher values of phenolic content.

Keywords

ultrasound; drying; pre-treatment; sonication; mushrooms

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O 25 - Listening to Ultrasonic Plant Vibrations

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Abstract

In vascular plants such as tomato, corn, zucchini and celery, drought stress leads to the generation of short ultrasound pulses [1]. The existence of these pulses has been known for some time and is caused by the formation of air bubbles in the Xylem [2-4]. However, the frequency spectrum of the ultrasound pulses was not understood until recently. The expertise within the Plantenna consortium has led to a collaboration between experts in the field of ultrasound and plant physiology. This unique combination pivoted a breakthrough in the understanding of the ultrasound frequency spectrum. By analyzing the frequency spectrum of each individual pulse, we are able to extract the properties of the Xylem without having to destroy the plant. By listening carefully to the plant, we can determine the diameter, elasticity, and length of individual Xylem vessel elements. As we can do this for each individual ultrasound pulse, it is possible to determine these parameters reliably using statistics. We have validated the developed method by testing the results against conventional destructive techniques that are normally applied.

In a horticultural relevant environment, the plants do not experience drought stress. As a result, it does not seem possible to determine the properties of the Xylem by means of ultrasound. To demonstrate the applicability of our method, we therefore showed in lab conditions that the short ultrasound pulses of the plants can also be driven externally. We sent short pulses to a vascular plant using ultrasound speakers and listened to what came back from the plant. To our surprise, we can find the same frequencies in the reflected sound as in the pulses generated by drought stress. By linking these data sets, we have been able to determine the properties of the Xylem in plants without drought stress.

Our technique paves the way for non-destructive measurements on the Xylem vessel of plants without the need for sensors and actuators on the plant itself. We believe that the technique developed by us realizes rapid phenotyping. One can think of selection on the basis of the vascular system, but also on the basis of the elasticity of the plant. A different application is the detection of wilt diseases in an early stage [5].

Keywords Ultrasound; Xylem; drought stress; elasticity; non-destructive sensing, Plant Physiology

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O 26 - One-minute and green synthesis of magnetic iron oxide nanoparticles assisted by design of experiments and high energy ultrasound: Application to biosensing and immunoprecipitation

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Abstract

In this work, a one-minute and green synthesis of magnetic (iron oxide) nanoparticles (MNPs) based on the co-precipitation method assisted by high energy ultrasound and design of experiments (DOE) is reported. This ultrafast process is based on the optimization of two main factors: energy (amplitude) of the ultrasound probe and the time of sonication. This DOE-based sonochemical strategy promotes important advantages with respect to typical and some new methods: reduction of reagents employed, use of water as solvent, low energy requirements and drastic saving of time, from hours to just one minute [1].

The final obtained product under the optimized operating conditions established according to DOE results produced MNPs with an average particle size of 11 ± 2 nm. The MNPs were completely characterized for their composition, size, structure, morphology and magnetization properties by means of different instrumental techniques: X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), transmission (Fig.1) and scanning electron microscopy (TEM/SEM), and vibrating sample magnetometry (VSM). The so-synthesized MNPs, showing probably a magnetite phase, were functionalized with different coatings agents like polydopamine and sodium citrate, among others.

These functionalized MNPs were successfully employed in two different applications, environmental and biomedical, respectively: i) biosensing detection of Hg^{2+} in water exploiting the inhibition caused by this ion on the horseradish peroxidase enzyme attached onto the polymer-coated MNPs surface; and ii) immunoprecipitation study in which polyclonal antibodies were anchored on the functionalized MNPs to react with an osteosarcoma cell line that expressed the target protein (TRIB2-GFP).

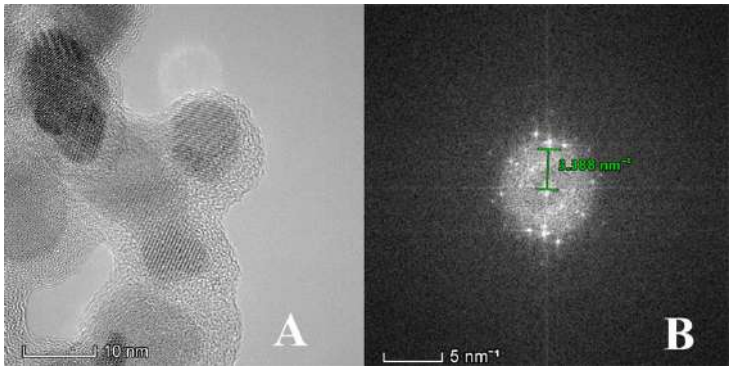

Figure 1. *Transmission electron microscopy (TEM) analysis of polydopamine (PDA)@MNPs. A) TEM micrograph of PDA@MNPs taken at HREM mode, B) Digital Diffraction Pattern (DDP) built from A.*

Keywords: Magnetic nanoparticles, 1 min-synthesis, design of experiments, high-energy ultrasound, biosensing, immunoprecipitation.

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O 27 - Nanocomposite Materials for All-Optical Ultrasound Imaging

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Abstract

Polydimethylsiloxane (PDMS) nanocomposites have broad applications in biomedical science. In particular, the development of highly optically absorbing PDMS nanocomposites have shown great promise in the emerging field of optical ultrasound generation. Here, the use of PDMS is advantageous due to its high thermal expansion coefficient, biocompatibility and compatibility with a wide range of fabrication methods. Using simple, scalable deposition methods, PDMS nanocomposites with micron-scale thicknesses can be created on the distal end of optical fibres. Ultrasound is generated optically *via* the photoacoustic (PA) effect; pulsed laser excitation is delivered to the optically absorbing nanocomposite at the fibre tip, resulting in a pressure rise that propagates as an acoustic wave. Due to their small lateral dimensions, these fibre-based devices are well-suited to applications in minimally-invasive interventions, transforming image-guidance from within the body.

Here we discuss a series of nanocomposite coatings that we have optimised for optical ultrasound generation. One particularly promising class of nanocomposites comprising multi-walled carbon nanotubes (MWCNT) and PDMS, demonstrates broadband optical absorption [1]. When applied onto optical fibres, these MWCNT-PDMS nanocomposites transform them into highly miniature ultrasound transmitters that achieve high ultrasound pressures (up to 1.85 MPa peak-to-peak, 3 mm distance) and broad frequency bandwidths (up to 30MHz at -6 dB), resulting in high-resolution imaging showing clinically-relevant features in benchtop and *in-vivo* studies [2]. However, the broadband optical absorption of the MWCNTs limits these devices to one imaging modality. By tuning the optical properties of the PDMS nanocomposites using gold nanoparticle or quantum dot optical absorbers, we demonstrate nanocomposites that exhibit high optical absorption within a narrow wavelength region for ultrasound generation, and high optical transmission in clinically-relevant regions for other sensing modalities such as photoacoustics, or for therapeutic applications. We explored this in the context of PA imaging; using 532 nm and 1210 nm or 1064 nm laser excitation sources for ultrasound and PA imaging, respectively, we acquired co-registered images of *ex vivo* human tissue that enabled us to obtain information on tissue microstructure with molecular contrast for lipids [3]. Fibre-based ultrasound transmitters coated with these nanocomposites will open up new avenues for multimodality imaging or combined imaging and therapies, with important potential clinical diagnostic and therapeutic applications such as the identification of atherosclerotic plaques in coronary arteries.

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O 28 - Ultrasonic monitoring provide the novel possibility to control the thrombolytic drug injection

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Abstract

The problem: several thrombotic situations, such as ischemic stroke and myocardial infarction, are extremely deadly but may occur suddenly [1]. The traditional thrombolytic treatment assumes, that thrombi have already formed and blocked the blood flow, and this therapy itself has a rather sufficient bleeding risk [2]. **The way of a solution**: for the last two decades, ultrasound methods have rapidly advanced - sensors have become miniaturized, technologies for continuous long-term monitoring of the flowing blood state directly in human vessels are raised [3]. It is essential that ultrasonic methods can detect blood coagulation under intensive flow conditions even in major arteries of the human body [4]. In the present study, we used real-time ultrasound Doppler monitoring to control the thrombolytic drug injection *in vitro* [5]. **Methods**: The original experimental set-up was designed. A closed system of flexible transparent silicone tubes was filled with blood or blood plasma. A peristaltic pump generated the flow of liquid. Digital camcorder performed optical registration of clots formation and dissolution. Acoustic registration was performed via an ultrasonic scanner working in a Doppler mode at a frequency of 5 MHz. Computer recorded and processed signals from both channels. A special automated drug-injector was designed to infuse the thrombolytic drugs into the experimental system. The injector delivered a fibrinolytic agent into the system in a precisely controlled and reproducible manner based on an ultrasonic signal. **Results**: ultrasonic Doppler monitoring provides the novel possibility to inject thrombolytic drugs even at the earliest stages of blood clotting. This approach allows in some cases to avoid large clots formation and, thus, to prevent thrombosis. We believe that this study would be the basis for further developments in the field of thrombosis fighting and this approach will be useful for intensive care units or reanimation wards.

Keywords

Ultrasonic monitoring; Doppler sonography; Blood flow; Blood plasma; Real-time; Blood coagulation;

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O 29 - High-speed photographic observation of the sonication of a rabbit carotid artery filled with microbubbles by 20-kHz low frequency ultrasound

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Abstract

The aim of this study is to assess the physical damage of cavitation effects induced by low frequency ultrasound and microbubbles (MBs) to an in vitro vessel. A rabbit carotid artery filled with SonoVue MBs and methylene blue was irradiated with 20-kHz ultrasound, and the results were recorded by high-speed photography at 3000 frames per second[Fig1]. The carotid artery filled with MBs experienced a slight tremor during ultrasonication. Six intermittent blue flow events occurred in two places on the artery wall during the 5-s process. The duration of each leakage event was 90-360ms with an average of 200ms. Hematoxylin-eosin (H-E) staining demonstrated the separation of the carotid artery elastic membrane, local blood vessel wall defects and hole formation, and the surface of the ruptured area was rough and irregular. Another carotid artery was filled with a 0.9% NaCl solution and methylene blue as a control and irradiated with 20-kHz ultrasound. No blue liquid flow was seen, and no holes in the vessel were observed. H-E staining revealed intact vascular endothelial cells and smooth muscles with no vascular wall defects. Low-frequency ultrasound combined with MBs can cause a vessel to rupture and holes to form in a short time. High-speed photography is useful for observing transient changes caused by the effects of ultrasound cavitation[1-3] on an in vitro vessel.

Figure 1. experimental equipment, including a high-speed camera, an ultrasonic probe, a rabbit carotid artery, and a water tank on the actual experimental site

Keywords

High-speed photography; Ultrasound; Microbubble; Cavitation; Rabbit carotid artery

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O 30 - Using ultrasound for preparation of aqueous fullerene dispersions as reference materials and their characterizations

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Abstract The solubility of fullerenes generally is low in any polar or non-polar solvent. In non-polar solvents, fullerenes make a true solution; colloidal solutions are obtained in aqueous media. Nevertheless, direct solubilization of a fullerene in water is a challenging chemical process. Ultrasonic-assisted treatment is the most successful method of dissolving fullerenes. For the first time, aqueous fullerene dispersions (AFD) were obtained by ultrasound-assisted solvent-exchange procedures from toluene to water. It is a reliable way to get concentrated, sedimentically stable, non-contaminated samples. The stabilization mechanism is still unknown and is being discussed. The primary organic solvent (e.g., toluene) and ultrasound may play a vital role in the stabilization mechanism. In aqueous media, fullerenes exist in a nanoparticle form with a wide size distribution. As well, the total yield in the ultrasound-assisted solvent-exchange procedure is generally low. Moreover, the concentration and characteristics of the colloidal solution of AFDs depend on the process used for obtaining the dispersion. To date, a reliable reference material of AFD has yet to be developed. Using the most investigated fullerenes, C_{60} and C_{70}, it is possible to render standard platforms of high antioxidant-activity nanozyme. An endohedral $Gd@C_{82}$ reference material would be applied for MRI and MRT. Thus, this study aims to (i) find out the optimum procedure for preparing a reference material (RM) of AFDs with the minimum precursor loss; (ii) determine a selection of methods for their comprehensive physicochemical characterization, and (iii) estimate the toxicity of the fullerene RM.

In our work, we used commercial off-the-shelf ultrasonic baths and probes made in Russia. We optimized the procedure for dispersion preparation by varying the following parameters: the electrical power of the ultrasonic equipment, the mass of the raw materials, the ratio of aqueous to organic phase, processing time, and processing temperature. All the details will be discussed in the presentation. We achieved the total fullerene concentrations for AFD C_{60} *ca*. 150 ppm with 60% total yield and $Y@C_{82}$ of *ca*. 10 ppm with 99% total yield. Some samples (AFD C_{60} and C_{70} with c~25 ppm) demonstrate long-term sedimentation stability, since December 2011.

We proposed a collection of methods for the complete chemical and general characterization of AFD samples. They include the assessment of (i) total fullerene content by TOC analysis, UV/vis, MALDI, and ICP-OES analysis (in the case of endohedral fullerenes with Gd, Y atoms); (ii) the residual quantity of organic solvents and their derivatives produced by sonication in an oxidative air atmosphere by FTIR, GC-MS, HPLC-UV; (iii) anion composition, in the case of a high-energy ultrasound probe; (iv) colloidal parameters akin to zeta-potential, particles size distribution; and (v) general characteristics akin to the pH and the boiling and the freezing points for evaluation storage parameters.

We proposed a collection of methods to be used for the complete purification of AFDs. We used solid-phase extraction for eliminating volatile organic content by GC-MS and the filtration on a syringe filter to remove TiO_2 nanoparticles resulting from the decomposition of the ultrasound probe by ICP-OES and FTIR. The pros and contras of using ultrasound bath versus immersible probe for AFD preparation will be presented.

Thus, a complete evaluation of the composition allows these products to be validated for biomedical applications. We used the MTT assay application for cytotoxicity to obtain a quantitative measurement of cell death for all produced AFD. Incubation of human fibroblasts with AFD of various concentrations was carried out. All the systems studied have shown a rather low cytotoxicity (cell survival rate of 90% and higher).

Keywords reference material; fullerenes; ultrasound probe; ultrasound bath; analytical chemistry

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O 31 - Verification of permanent bolt elongation during assembly using ultrasonics

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Abstract

The permanent elongation of M14 fasteners tightened into the plastic range of the material using a yield control method are audited in production using ultrasonics and two mechanical measurement methods with dials. The ultrasonic method is based on measuring the time of flight (TOF) and correlating it with measurements using a load cell. The ΔTOF in the tightening system is shown as clamp force [kN]. In initial laboratory experiments, tightening is carried out to assure the permanent elongation of the fastener, load is measured by the tightening tool system and with a load cell in the joint. The fasteners are removed from the joint and the permanent elongation is measured mechanically. In this fashion a graph is generated with permanent elongation as a function of the ultrasonic clamp force. A PowerMACS 4000 system with a QST62-350CT nutrunner is used in the experimental setup and production. An ultrasonic signal processing unit using a piezoelectric sensor fitted to the socket is used for signal generation and processing when evaluating clamp force. The ultrasonic clamp force control is based on a novel method for assuring correct echo and high repeatability measurements in the tightening system [1]. Torque, angle and gradient are extracted from the tool control system.

The results (Table 1) show that the ultrasonic measurements (US audit) are within 13 µm difference from the mechanical measurements. The method allows every tightened bolt to be evaluated at the end of the tightening process.

[mm]	Scania audit	ACIT audit	US audit
Mean elongation	0.195	0.177	0.182
Max	0.272	0.257	0.276
Min	0.144	0.105	0.133
3s	0.113	0.117	0.124

Table 1. Permanent elongation measured using mechanical measurement according to Scania method, Atlas Copco method and US audit method.

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O 32 - Ensuring Cavitation in a Medical Ultrasonic Cleaner

Jahan Azizi

Providing a clean and functional medical device is critical to the prevention of nosocomial infection transmission. The use of a medical ultrasonic cleaner (i.e. sonic cleaner) is a major step in the cleaning process to obtain that goal. The cavitation process dislodges debris and remove soil from joints, crevices, lumens, and other areas that are difficult to clean using other methods. It is important to ensure cavitation is occurring in a medical sonic cleaner because if it is not functioning properly, then the unit essentially becomes an expensive soaking tank.

The United States Food and Drug Administration (FDA) classify the ultrasonic cleaner as a Class 1 medical device “intended for cleaning medical instruments by the emission of high frequency soundwaves.” ANSI/AAMI ST79:2017 indicates Ultrasonic cleaning equipment is not designed for disinfection or sterilization. Ultrasonic cleaning equipment should be used for fine cleaning, to remove soil from joints, crevices, lumens, and other areas that are difficult to clean using other methods. AAMI recommends cavitation testing be performed daily.

AAMI recommends that medical facility personnel ensure their ultrasonic cleaners are producing cavitation and have the ability to remove a test soil from external and internal surfaces of items cleaned ultrasonically, it is essential to ensure that the verification products used to test ultrasonic cleaners are actually testing for the correct parameters and that the statements made in the testing product IFUs are accurate. Health care facility personnel should understand exactly what these products are testing for, the significance of the ultrasonic cleaner passing the test, and what it means when the cleaner fails the test.

Ensuring that ultrasonic cleaners are working correctly has been a concern for quite some time because there have not been many options for objectively testing ultrasonic cleaners to ensure they are functioning as they should be. Sterile processing team members have had only subjective tests such as the foil test (ie, a piece of aluminum foil is placed into the ultrasonic bath and observed for perforation or destruction caused by cavitation), glass slide test (ie, the frosted portion of a glass slide is marked, placed into the ultrasonic bath, and observed for removal of the mark), and ceramic disc test (ie, an unglazed ceramic disc with a flat finish is marked with pencil, placed into the ultrasonic bath, and observed for removal of the marks). The test results may not always be clear because each of these tests require subjective interpretation. The glass slide and ceramic disc tests demonstrate the removal of soil from a surface, but do not specifically detect cavitation. The foil test detects cavitation; however, the findings of pings and dimples in the foil must be subjectively interpreted by personnel and compared to the original test.

METHODS

A simple test of 4 products side by side using a mason jar containing cleaning solution with no cavitation energy generated. Four Mason jars were filled with 500 mL of utility water mixed with a hospital approved cleaning solution at a dilution of 1/2 oz per gallon of utility water as per the manufacturer’s IFU and a temperature of 77° F (25° C). The test was repeated with four Mason jars filled with 500 mL of utility water mixed with the cleaning solution at a dilution of 1/2 oz per gallon of utility water and a temperature of 100° F (38° C). Both tests were repeated three times. The temperature of the solution in each jar was verified by inserting a temperature probe into the cleaning solution immediately before the test products were placed into the jars. The jars were agitated by vigorous manual shaking for 5 seconds once each minute for 15 minutes. The results of the testing products were interpreted according to their manufacturer’s IFU and recorded after the 15-minute simulated cavitation process. The 15-minute time frame was chosen because it is the standard time used at the researchers’ facility for ultrasonic cleaning of instruments. Two temperatures were chosen to keep the test design simple. Only one cleaning solution was used. The cleaning solution was diluted in accordance with the manufacturer’s IFU.

DISCUSSION

Since ultrasonic cleaning is the combination of mechanical (cavitation) and chemical (cleaning solution) cleaning, being able to distinguish between these different processes and to demonstrate which are occurring and which are not occurring is vital to solving cleaning issues and ensuring effective ultrasonic cleaning of medical devices. Sterile processing and biomedical personnel should understand these different parameters and should know how to test for the components essential to effective ultrasonic cleaning (eg, temperature, cleaning solution, cavitation, cleaning ability). These tests should be part of the facility’s quality management program (QMP) where the testing that is performed by facility personnel is known as a performance qualification step. Incorporating a QMP into the facility’s ongoing processes for verifying effective ultrasonic cleaning will reduce the risk of patient infection and improve patient outcomes.

The results of this study showed that three of the four products failed to accurately assess cavitation because the dye/soil was removed when there was no cavitation present. These

products appear to be sensitive to temperature and the presence of a detergent. It is likely that the longer the product remains in the solution, the more opportunity there is for the dye/soil to be removed from the coupon. Product A, which is enclosed in a sealed, fluid-tight system is not affected by its surroundings unless there is cavitation present. Product A was the only product shown to demonstrate the absence of cavitation and was the product in use at the researcher's facility. This study corroborated that the correct product was being used.

CONCLUSION

Cavitation is an important and necessary function of all ultrasonic cleaners and is the reason these units are so important for effective cleaning of medical instruments. This study was conducted to identify a method to verify cavitation testing of several products designed for this purpose and currently available on the market. The Mason jar method described in this study provides a simple method for simulating an ultrasonic bath where no cavitation is present. The results of the study clearly demonstrate that even when no cavitation is being produced, some of these tests will provide passing results. Therefore, those tests do not distinguish between cavitation production and the other parameters in an ultrasonic cleaner.

O 33 - Focused ultrasound-enhanced drug delivery to the brainstem

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Abstract

Diffuse intrinsic pontine glioma (DIPG) is a high-grade glioma that originates in the pons of the brainstem. It constitutes 15–20% of all pediatric central nervous system tumors but is the single greatest cause of brain tumor-related death in children. The location and diffuse nature of the disease prohibit surgical interventions. At the same time, conventional chemotherapy shows little improvement in survival, presumably because drug delivery is limited by the often intact blood-brain barrier (BBB). We showed that focused ultrasound (FUS) combined with microbubble-induced BBB disruption (FUS-BBBD) could safely enhance the delivery of intravenously injected agents to the brainstem of wild-type mice [1] and genetic-engineered DIPG mice [2]. We also demonstrated that large volume, homogeneous drug delivery to the brainstem could be achieved using an optimized treatment protocol. Moreover, to minimize systemic exposure associated with intravenous injection, we performed FUS-mediated intranasal delivery (FUSIN) and achieved localized drug delivery to the brainstem with minimized systemic exposure[3]. We compared these two FUS-mediated drug delivery techniques. We found that FUSIN could achieve higher delivery efficiency to the brainstem and lower exposure to peripheral organs (e.g., heart, lung, liver, and kidney) than FUS-BBBD [4]. We also showed that FUSIN enhanced the delivery of intranasally administered anti-programmed cell death-ligand 1 (PD-L1) antibodies to brainstem gliomas. These findings suggest that FUS provides a promising approach to overcome the BBB for the noninvasive and localized drug delivery to the brainstem with the potential to be applied in the future for the treatment of DIPG.

Keywords

Focused ultrasound; Drug delivery; Brainstem; Brain tumor; Diffuse intrinsic pontine glioma

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O 34 - Anisotropic Focusing Transducers in Thin Piezoelectric Films

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Abstract

This article describes a theoretical framework and experimental investigation of focused beams in piezoelectric thin films in anisotropic material. Previously focusing transducers have been explored to couple to wavelength scale structures for the case of in-plane isotropic piezoelectric materials and to avoid anchor losses in “Gaussian Focused-Cavity Resonators” designed to increase quality factor by concentrating the mode energy toward the resonator center while also maintaining coupling coefficient1-3. However, recently the availability of lithium niobate on insulator material has catalysed exploring LN for high frequency applications4. These attractive materials have a high degree of anisotropic and therefor the isotropic framework doesn’t apply. In this work we develop a methodology to achieve focusing in anisotropic materials. A mathematical formalism describing focused acoustical beams in anisotropic material is presented and related to their optical counterparts. A novel Fourier domain transducer design methodology is presented and utilized to produce near diffraction limited focused beams using thin lithium niobate on silicon. The properties of the acoustic beam formed by the transducer were studied by means of Doppler vibrometry implemented with a scanning confocal balanced homodyne interferometer. Fourier domain modal analysis confirmed coupling efficiency to the targeted mode. Comparison of isotropic and anisotropic transducer design demonstrates the advantage of anisotropic design to achieve tighter focusing and more efficient coupling to wavelength scale structures in anisotropic films.

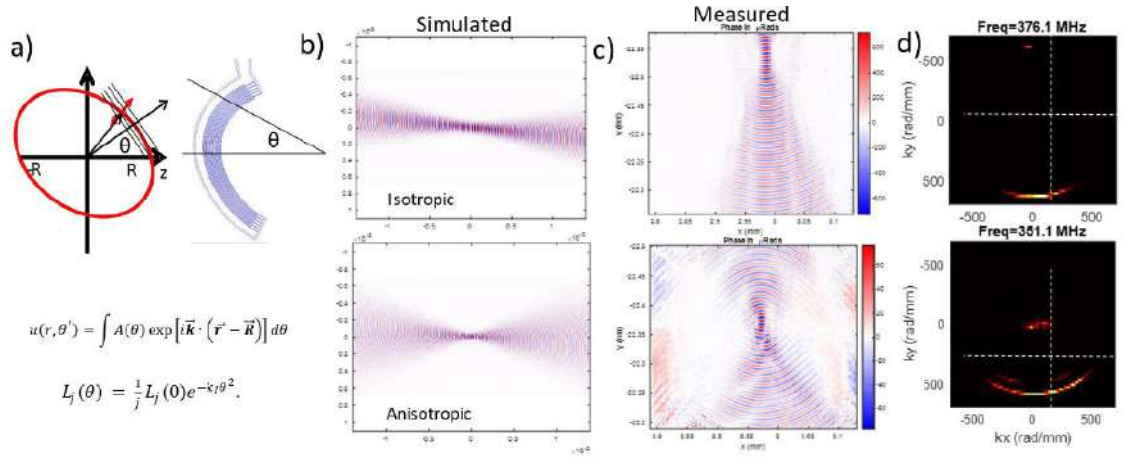

Figure 1. *(a) Transducer synthesis from dispersion (b) Simulated beam generated from focused transducer design (upper) and anisotropic transducer design (lower) which has a tighter focus (c) Measured beams from isotropic transducer design (upper) and anisotropic transducer design (lower) illustrating tighter focus with anisotropic design. (d) Fourier domain representation of measure data in (c). The isotropic design loses coupling in the wings compared to the anisotropic design which is responsible for the loose focus.*

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Shotgun Presentations

SG 01 - Sonochemical activation as a novel strategy for the synthesis of water-soluble monosubstituted Ru(II,III) compounds

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Abstract

The use of alternative activation methods such as ultrasound-assisted synthesis has been gaining interest in recent years in order to contribute to a greener synthesis [1]. The cavitational physical phenomenon for preparation of organic or inorganic material, degradation of pollutants or extraction of bioactive compounds from biomass feedstock has become a well-established chemical process [2]. The use of amidinate ligands in paddlewheel diruthenium chemistry to obtain partially substituted compounds has made possible to obtain derivatives with outstanding properties and high applicability in biotechnology and biomedicine fields [3]. For the first time, we have used sonication-assisted synthesis as a new approach to obtain partially substituted complexes with metal-metal bond. Here, we report the full characterization, properties study and discussion of synthesis method for six monosubstituted Ru(II,III) compounds of type $[Ru_2Cl(OAc)_{4-n}(L)_n]$ (n = 1) using *N*,*N´*-donor bridging ligands such as formamidinato (HDArylF).

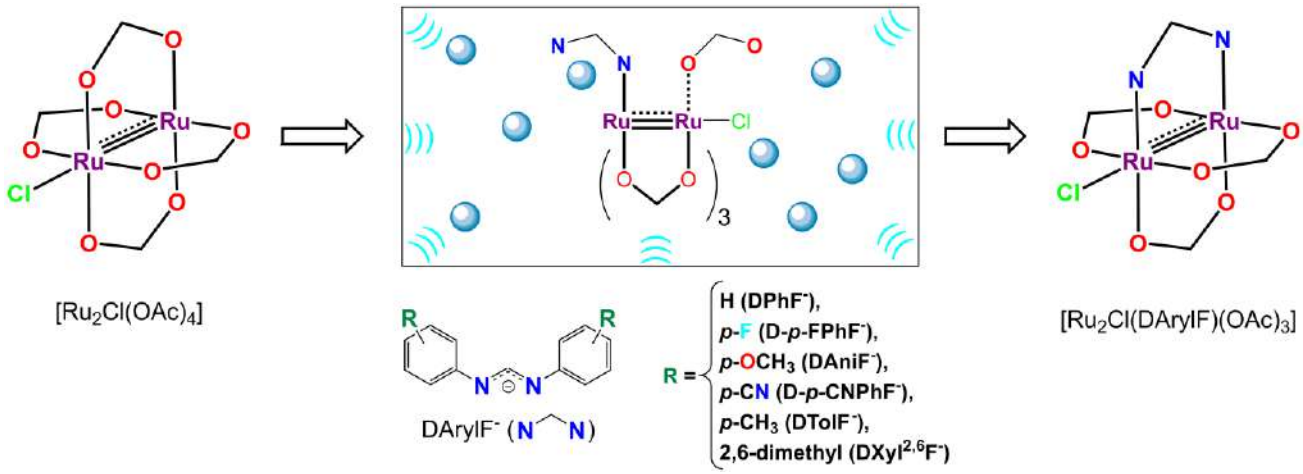

Figure 1. Sonochemical activation of a diruthenium compound with metal-metal bond to obtain six partially substituted derivatives in greener conditions using symmetrical N,N´-donor bridging ligands.

Keywords

diruthenium; metal-metal bond; green chemistry; water-soluble compounds

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The authors gratefully acknowledge to Comunidad de Madrid for Project S2017/BMD-3770-CM. Aarón Terán acknowledge to Universidad Complutense for a Predoctoral Grant (CT63/19-CT64/19) and to the Spanish Ministry of Science and Innovation for a Posgraduate Fellow at Residencia de Estudiantes (2020-2021).

SG 02 - Pro-Inflammatory effects of 1-MHz Pulsed Ultrasound in Human Keratinocytes

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Low intensity pulsed ultrasound (LIPUS) of ~1-MHz frequency has been widely applied since the 1950s for both therapeutic and diagnostic tool [1]. The extensive clinical application of LIPUS suggests the need to better understand the related biological effects which are mostly linked to mechanical stress [2]. In this framework, we investigated whether mechanical energy transported by 1 MHz LIPUS could generate a mechanical stress able to modulate and induce the release of inflammatory cytokines such IL-6 in a human keratinocyte cell line (HaCaT). Human keratinocytes are often used to study epidermis homeostasis and its pathophysiology. In particular, these cells respond to both chemicals and physical agents, reporting a different production of cytokines, such as IL-1 and IL-6, in relation to the stimulus and the dose of the stimulus [3].

At first, we analysed the gene expression and protein secretion of the pro-inflammatory cytokine IL-6 by Real Time-qPCR and ELISA, respectively, at varying exposure parameters. Then, we focused on the activation of Nuclear Factor-κB (NF-κB), a pleiotropic regulator of many cellular pathways involved in cytokine production, cell-cycle regulation and apoptosis. Related effects on the cell cycle distribution and apoptosis have been also evaluated through flow cytometry analysis and by following the gene expression of Bax/Bcl-2.

Our results pointed out that 1 hour exposure of 1 MHz LIPUS at spatial-peak temporal-average Intensity (I_{spta}) of 65 mW/cm^2 (Figure 1a) promotes both significant IL-6 gene overexpression and protein secretion (Figure 1b), associated with the activation of Nuclear Factor-κB (Figure 1c). Furthermore, we observed a reduced cell viability dependent on exposure parameters together with alterations in membrane permeability and cell proliferation, paving the way for further investigating the molecular mechanisms related to ultrasound exposure.

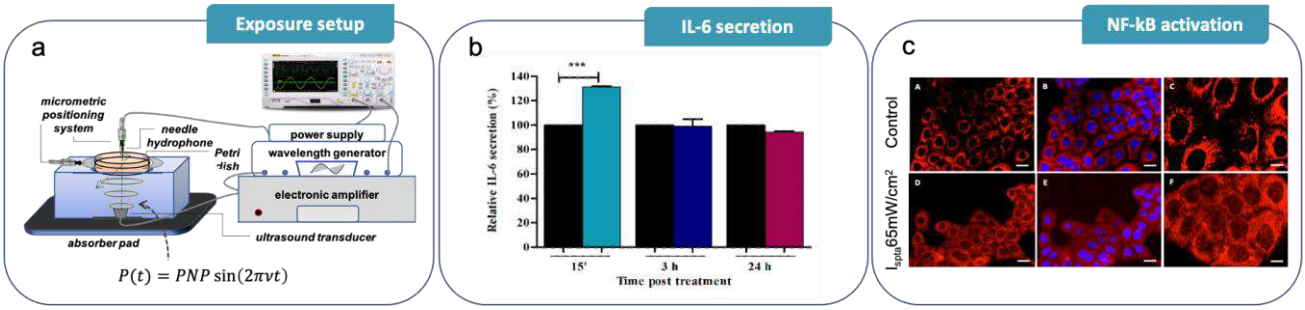

Figure 1. In vitro analysis of pro-inflammatory effects induced on keratinocytes exposed for 1 h to 1-MHz LIPUS (10% duty cycle and pulses of 300 μs) at Ispta = 65 mW/cm2. (a) Sketch of the exposure setup (SSD = 7 cm); (b) IL-6 secretion analysed by ELISA assay in cultured media of HaCaT cells untreated (black histograms) and exposed to LIPUS, followed by different times of recovery; (c) Immunofluorescence analysis of HaCaT cells untreated (A-C) and exposed to LIPUS (D-F), HaCaT cells were stained with anti-p65 NF-κB (red) and Hoechst (blue). Scale bars measure 15 μm (A-B, D-E) and 5 μm (C, F).

Keywords: Keratinocytes; LIPUS; Interleukin-6; Nuclear Factor-κB

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Acknowledgements: This research was realized with the financial support of INAIL under the agreement BRIC2019 ID 43.

SG 03 - Luis Carvalho

SG 04 - A methodology to conduct ultrasonic fatigue tests at 20kHz (on metallic specimens)

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Today, the design of structures subjected to cyclic loading with a number of cycles beyond one billion (field of the very high cycle fatigue domain, VHCF) requires particular attention. For this type of loading, conventional testing machines, operating at a few tens of Hz, are not suitable because they lead to prohibitive testing times (several months or more). More recently, ultrasonic fatigue machines operating at 20 kHz have been developed to quickly characterize the fatigue behavior of metals in the VHCF domain. For instance, with this type of machine one test until one billion cycles lasts less than one day. This ultrasonic fatigue machine is composed of a high voltage ultrasonic generator and a converter which consists of a series of piezoelectric stacks which transforms the electric signal into a displacement. A horn placed on the edge of the converter which amplifies the vibration applied to the fatigue specimen.

This communication aims to present the metrological aspects of the ultrasonic setup and how it is used to carry out fatigue tests. As an initial overview, a metallic specimen (in the scope of this study) is screwed to the amplifying horn on the edge of the full setup. This specimen is then made to vibrate in its 1st longitudinal mode of vibration which corresponds to a tension/compression loading. According to the power supplied to the machine, the amplitude of this loading can be controlled. To master the loading amplitudes, two methods are used:

• Strain gauges placed on the specimen measure its total strain during the loading,

• A laser vibrometer put in front of the free end of the specimen which measures its displacement amplitude.

This ultrasonic machine thus allows to quickly characterize the fatigue behavior of (metallic) materials in the VHCF domain.

The presentation will focus on the description of the machine with a mechanical point of view and will then depict the setup with an electronic approach considering the resonance frequencies and the different configurations of the system. The author's understanding of the machine operation will be exposed and the way the authors consider it to design the fatigue specimens will be presented.

Acknowledgements

This study was conducted in the framework of the European research project H2020 FastMat (fast determination of fatigue properties of materials beyond one billion cycles) financed by the European Research Council (ERC) (grant agreement No 725142)

SG 05 - Time resolved X ray diffraction applied to ultrasonic fatigue loading

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Today, the design of structures subjected to cyclic loading with number of cycles beyond one billion (field of the very high cycle fatigue domain, VHCF) requires particular attention. For this type of loading, conventional testing machines, operating at a few tens of Hz, are not suitable because they lead to prohibitive testing times (several months or more). More recently, ultrasonic fatigue machines operating at 20 kHz have been developed to characterize quickly the fatigue behavior of metals in the VHCF domain. For instance, with this type of machine one test until one billion cycle last less than one day. This ultrasonic fatigue machine is composed by a high voltage ultrasonic generator and a converter composed by a series of piezoelectric stacks which transforms the electric signal into a displacement. A horn placed on the edge of the converter allows to amplify the vibration applied to the fatigue specimen.

The aim of this communication is to present a new methodology and experimental technique to characterize quickly the fatigue behavior in the VHCF domain. This method requires additional measurements such as the self-heating of the specimen using infrared thermography and the evolution of the longitudinal stress during a cycle (50µs) by X-ray diffraction. For this last measurement, taken into account of the extremely short time resolution for about 0.1 ns, it is necessary to use intense X-ray sources such as synchrotron radiation and to use a stroboscopic method to cumulate integration times in order to obtain diffraction patterns with a sufficient signal to noise ratio . To reach this extremely short time resolution, the synchrotron is used in a pulsed mode and the vibration of the piezo electric fatigue machine is synchronized with the revolution period of electrons in the storage ring of the synchrotron.

To ensure the synchronization between the ultrasonic fatigue machine and the synchrotron, we have developed a power voltage generator which is controlled by a phase locked loop which synchronizes with the target frequency of 20 158 Hz, which corresponds to a multiple of the revolution period of electrons (~1.1820µs). The methodology and the results will be presented and discussed.

Acknowledgements

This study was conducted in the framework of the european research project H2020 FastMat (fast determination of fatigue properties of materials beyond one billion cycles) financed by the European Research Council (ERC) (grant agreement No 725142)

SG 06 - RLS QRD Lattice Algorithm for Hand Detection in Ultrasound-Based Applications

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Abstract

In this work RLS QRD Lattice Algorithm is used as a new approach of a pre-processing stage for hand detection purposed for ultrasound-based applications. The principle of hand detection in this work is based on noise cancellation technique described in details in [1]. The RLS QRD Lattice algorithm was supplemented with hypothesis testing [2, 3] to improve robustness and accuracy of decision-making while removing undesired responses from the source signal. During experiments, two identification models were constructed. The first regression model has an order higher enough to cover all data coming from the sensor. The second regression model is of a smaller order and with time delay. The settings of the second model are chosen under assumption that it covers the space where there is no hand appearance possible. During estimation process of newly incoming data the algorithm has to choose, which of two models suit best for the given situation. The results of experiments are shown in Fig.1.

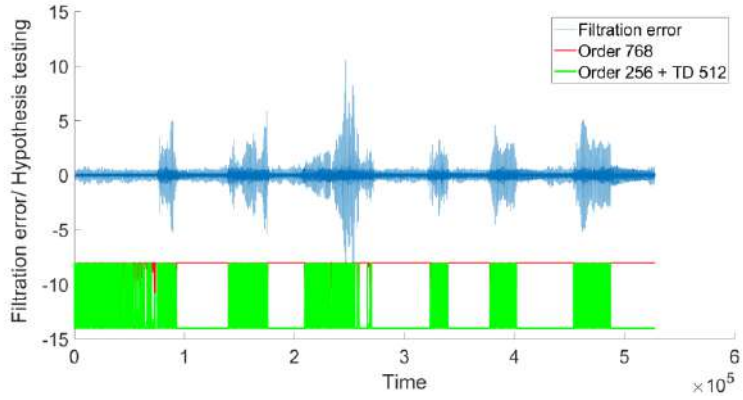

Figure 1. *RLS QRD Lattice algorithm – single precision floating point*

Due to the algorithm structure, pipelining and parallel processing techniques can be applied. As far as the algorithm is purposed to be mapped on embedded Zynq Ultrascale+ device, it was modified to accelerate computation process [4].

Keywords

RLS QRD Lattice algorithm; hand detection; noise cancellation; parallel processing; pipeling

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Acknowledgements

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SG 07 - The impact of ultrasound pre-treatment on strawberry microstructure

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Abstract

The use of ultrasound treatment as a pre-treatment causes modifications in food quality. Microstructure and its changes in food can be used to assess the influence of the process on the material. In plant tissue treated with ultrasound, numerous alterations in the structure occur. The cellular structure becomes disordered and the degree of its degradation increases with increasing duration of treatment [1].

The aim of the study was to analyze the microstructure of strawberries treated with ultrasound with different parameters (power and time of treatment). The whole strawberries were subjected to the pre-treatment, which was carried out with the use of ultrasonic bath working with a frequency of 21 kHz and a power of 180 or 300 W for a time from 0 to 60 minutes. For the microstructure study, the raw material and ultrasound treated tissue was cut into 5 mm slices and frozen at -40 °C and freeze-dried in a freeze drier at a pressure of 63 Pa and temperature of 30 °C for 24 h. In order to produce SEM images, small pieces were taken from the samples and put into the vacuum chamber. Image analysis was conducted using MultiScan v. 13.11 software. Measurements of the cross-section area were carried out for each cell. The histograms of the measured values were calculated using Microsoft Excel 2013.

The ultrasound pre-treatment modified the microstructure of the strawberries tissue. The pictures made with scanning electron microscope show an increase in the intercellular spaces, folding of the walls, and the formation of microchannels, which increased in size with the increase in the time of treatment and with the higher power of ultrasonic waves. This was confirmed by the quantitative analysis of the cross-section areas, which was calculated on the basis of SEM photos. The histogram of cross-section areas of the sonicated strawberries tissue was shifted toward larger field areas in comparison to the untreated sample. Moreover, the higher power and longer treatment time caused a shifting towards larger fields. It means that longer treatment results in more significant changes in strawberry tissue. Additionally, the creations of microchannels in freeze-dried strawberry tissue were observed (Fig. 1).

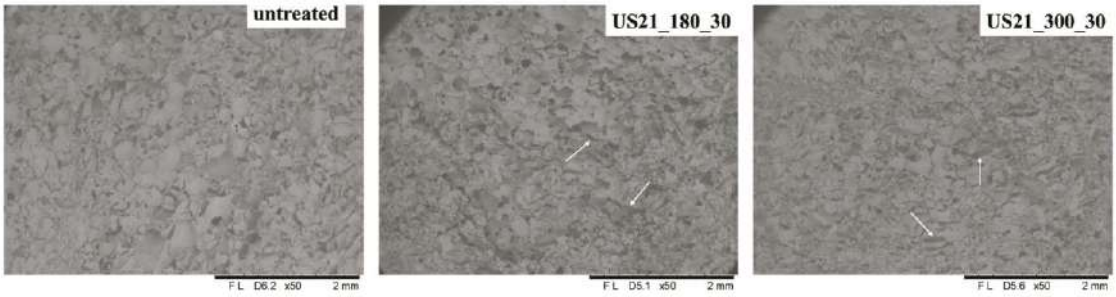

Figure 1. *Structures of the untreated and ultrasound treated freeze-dried strawberries made using the scanning electronic microscope after 30 min of ultrasound treatment at frequency 21 kHz and power of180 or 300 W (magnification 50). The microscopic channels were marked with arrow.*

Keywords

ultrasound; pre-treatment; sonication; microstructure, strawberry

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Acknowledgements

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SG 08 - The use of ultrasound to activate the aluminium oxidation by water

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Abstract

This work is devoted to the study of the environmentally friendly low-temperature (up to 100°C) process of aluminum powders oxidation by water to obtain gaseous hydrogen. The use of ultrasonic activation ensures almost complete oxidation of micron-sized aluminum powder by water without contaminating the oxidation products with the used activators. In addition, the use of ultrasonic activation in conjunction with chemical (calcium oxide additives) allows controlling the process: not only the rate of hydrogen release, but also the structure of the formed aluminum hydroxide. The possibility to synthesize solid oxidation products having a given composition, purity, and particle size makes it possible to significantly increase the economic attractiveness of the technology for the simultaneous production of hydrogen, heat, and aluminum hydroxide. This possibility becomes more important when using high power plants.

The work analyzes various aspects of the implementation of aluminium oxidation: the power and configuration of the ultrasonic field, various thermal modes of the oxidation process, the ratio of Al:H_2O reagents, the amount of chemical activator used and the method of its introduction with simultaneous use of ultrasonic activation. It is shown that ultrasound promotes the nucleation of aluminum hydroxide and the mass transfer of hydroxide from the surface of oxidizing particles to growing crystals. Ultrasonic activation is most effective at close to room temperatures. In this case a synergistic effect of simultaneous use of ultrasonic and chemical (CaO) activation is observed (Fig.1). The effectiveness of ultrasound with its short-term exposure at the beginning stage of intensive oxidation is shown. High rates of aluminum oxidation with the combined use of activation methods (line 3 and 4 at Fig.1) are due to the more intense nucleation of aluminum hydroxide crystals in comparison with the case of using only ultrasonic (line 2) or only chemical activation (line 1).The use of ultrasound makes it possible to obtain various types of oxidation products depending on the conditions of the process. Ultrasound accelerates the process of forming a structure known as a "nanowalls" and provides the formation of aluminum hydroxide crystals of various sizes including nanoparticles.

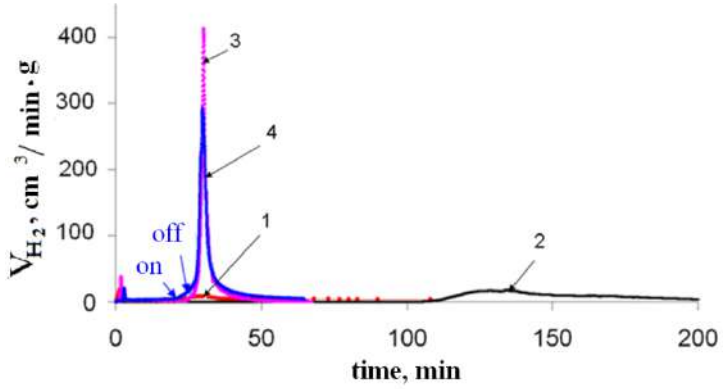

Figure 1. Micron-sized aluminium powder oxidation rate as function of time at the isothermal conditions. 1 - the use of chemical activation, 2 – the use of ultrasonic activation, 3 – the use of chemical and ultrasonic activation (continuous ultrasound), 4 – the use of chemical and ultrasonic activation (short-termultrasonic mode). “On” on the figure is time when ultrasound was turned on, “off” is time when ultrasound was turned off.

Keywords

aluminium oxidation; ultrasound activation; sonochemistry; hydrogen generation; aluminium hydroxide

SG 09 - Design and characterization of a new multi-frequency semi-pilot ultrasonic tank

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Nowadays, the requirement for process intensification in the chemical industry no longer only meets the economic considerations but also at the necessity to anchoring the industrial production in a sustainable approach, cleaner and more energy efficient technology. The phenomenon of cavitation, whether of hydrodynamic or ultrasonic origin, is likely to generate beneficial effects recognized as conducive for scale-up operations. Technically, the extrapolation of laboratory experiments on an industrial scale consists in taking into account the numerous constraints related to the production of large quantities of materials (impurities of the raw materials, duration of process, reliability, etc.) in large reactors. Thus, the development of a production line requires the realization of a pilot unit that will solve the problems encountered during the climb to scale-up. Therefore, many laboratories have been engaged in this way for a few years and the number of publications on pilot units [1], whether dedicated to ultrasonic or hydrodynamic processes, has considerably increased these last years. In this sense, he is interested in the basic considerations of cavitation phenomena on the industrial scale through some reminders and representative examples. A new model of sonochemical reactor emerged following the ULTRAFLAX project at UCEIV laboratory. This reactor is a multi-frequency ultrasonic tank with a maximum capacity of 30 litres (figure1) that allows the control of operating conditions including time, temperature, power and frequency. The interest of this multi-frequency tool is to be able to work with a varied range of powers and thus to offer a versatility in the number of experiments implemented according to the frequencies used. In order to determine the optimum sonochemical synthesis, the study of transient cavitation is carried out using the Weissler method [2], the sonochemical effects are measured by quantifying the production of triiodide ions during the implosion of cavitation bubbles. The dissipated ultrasonic power is evaluated by calorimetry [3]. The purpose of these characterizations is ultimately to optimize the sonochemical treatments, the results obtained at 20/40 and 100KHz for different powers suggest that the phenomenon of cavitation is greater at 1000W and at high frequency but is no longer detected at 250W unlike the low frequencies. Since the determination of triiodide ions does not reflect the mechanical effects of ultrasound, oxidation experiments such as TEMPO oxidation [4] of flax fibres are carried out in parallel in order to corroborate the results of the previous characterizations.

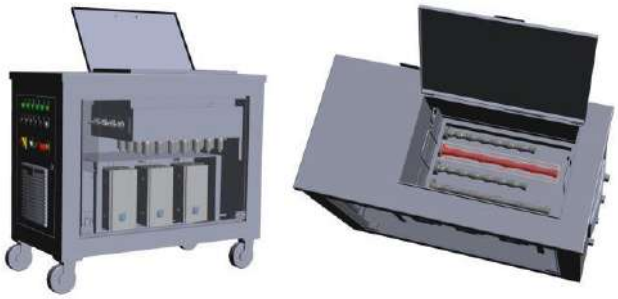

Figure 1. *Design of a semi-pilot US bench for the study of cavitation*

Keywords: ultrasonic; multifrequency; sonochemistry; Oxidation

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Acknowledgements : We thank the Haut-de-France Region for its contribution to the ULTRAFLAX project.

SG 10 - Hypericin under ultrasound exposure is able to provoke a significant anticancer effect on an in vitro three-dimensional colon cancer model

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Abstract

One of the main advantages of using ultrasound (US) in combination with a chemical agent (sonosensitizer) is the ability to maximize its anticancer activity in the so called sonodynamic therapy (SDT). SDT shares common features with the clinically approved photodynamic therapy (PDT), distinguishing itself by the use of US instead of light to achieve a better tissue penetration. The way in which SDT achieves cytotoxic effects remains still under debate, but one of the main activities involves the sonosensitizer-mediated reactive oxygen species (ROS) production [1]. In this work the anticancer activity of hypericin (HYP), a well-known photosensitizer, was investigated under US stimulation on an in vitro three-dimensional (3D) colon cancer model. The focus on 3D model is important since cancer cells organized into 3D structure share similar aspects of solid tumour, serving as a more feasible tool before moving to the in vivo setting compared to two-dimensional (2D) cell culture models [2]. The effects of US exposure of HYP have been studied on a human colon cancer (HT-29) cell line grown into 2D monolayers or 3D spheroids by coating 96-well plate with agarose. The synergic activity of HYP in combination with US was assessed by evaluating treatment effects on cell growth and cell death, by cytofluorimetric assays and confocal imaging. In order to select the proper non-cytotoxic concentration of HYP and the proper time to perform SDT, cytotoxicity assays and cytofluorimetric evaluations of cellular uptake were performed, resulting for 2D cell cultures 0.1 µM HYP for 24 h incubation, and for 3D spheroid cultures 0.2 µM HYP for 24 h of incubation. On 2D HT-29 cell cultures, SDT showed a strong effect 48 h after the treatment, and on 3D HT-29 spheroids, SDT induced a significant decrease in spheroid volumes also 48 h after the treatment. Moreover, it was also investigated the effect of SDT with HYP on HT-29 cells resistant to chemotherapeutic drugs such as doxorubicin. Data point out that the US exposure of HYP is able to trigger a significant anticancer activity on 2D and 3D colon cancer models.

Keywords

Sonodynamic therapy (SDT); ultrasound (US); hypericin (HYP); three-dimensional (3D) spheroids.

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SG 11 - Is ultrasound one of the most important tool in the diagnosis of Crohn's disease?

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Abstract

Introduction:

Crohn's disease (CD) is a chronic, autoimmune and inflammatory disease. It can occur at any age, but the usual onset is between 20 and 40. Currently, ultrasound examination is increasingly used in diagnostics of inflammatory changes in the intestines. It allows for an accurate assessment of the extent of lesions, as well as evaluation of possible complications of the disease and response to treatment.

Materials and Methods:

36 children were included in the study: 16 boys and 20 girls with an active phase of Crohn's disease. Each patient underwent intestinal ultrasound examination with a high frequency 7-12 Mhz linear probe.

Results:

All patients, who underwent US examination, had a thickened, hypoechoic wall of the ileum, showing patterns of vascularization. In 16 patients, inflammatory infiltration of the periintestinal fat around the affected intestine was visible. Bauhin's valve was swollen in 8 patients. Additionally in all patients, mesenteric lymphadenopathy with a short-axis diameter of 10–15 mm was found. In 8 children penetrating complications of the disease were seen - 4 small intestine fistulas and 4 abscesses.

Conclusions:

Ultrasound examination is a non-invasive and well-tolerated method of assessing CD activity and possible complications. It does not use ionizing radiation, therefore it is especially useful in patients who require multiple follow up. Due to the safety profile and diagnostic effectiveness of ultrasound, it should be regarded as the first-line imaging method in the assessment of inflammatory bowel disease in children.

Keywords

Ultrasound examination; Crohn's disease; Diagnostics of IBD; Assessment CD activity; Inflammatory bowel disease.

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Acknowledgements

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Poster Presentations

P 01 - Ultrasound responsive microdroplets as a synergistic gene-drug delivery agent on human Melanoma cells

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Cellular drug resistance and targeted drug delivery are critical issues of modern cancer nanomedicine research. Micrometric and sub-micron droplets (MD) represent a valid platform for delivering drugs (e.g. Anthracyclines) in the vascular system until they reach the tumor site, limiting the side effects of treatments and facilitating the transport of organic molecules, enclosed in MDs core, in polar environments, such as biological fluids. [1] At the same time, the high affinity for cell membranes of the dimethyldioctadecylammonium bromide (DDAB) MDs shell is exploited to transfect nucleic acids in cells. In so doing, specific tumor pathways can be modulated by means of siRNAs and specific consensus sequences transfection. From then on, we have developed MDs made of DDAB shell and a liquid perfluorocarbon (PFC) core able to effectively load a drug into the core [2] and bind DNA on the DDAB shell, at the aqueous interface. This high density and low polydispersion PFC-MDs system is obtained by ultrasound homogenization and it has already shown envaluable potential as a drug delivery carrier. [2] Herein, we present promising results about stability and cytotoxicity of MDs coupled with DNA. This system it is not only able to release Doxorubicin but it is also an efficient DNA non-viral vector transfection into a human melanoma cell line (Sk-Mel 28). By synergistically combining the MDs ability to release and transfect organic chemical entities, a simple but effective system is obtained in treating tumor. This type of approach is proposed as a valid treatment of tumors in the context of non-viral gene therapy compared to the widespread but invasive radio- and chemotherapies. [1] Moreover, by employing acoustic droplet vaporization (ADV) and medical ultrasound it is known that is possible to transform MDs into envaluable, theranostic-relevant echogenic microbubbles, helping extravasations, boosting drug release and its cellular uptake via cavitation.

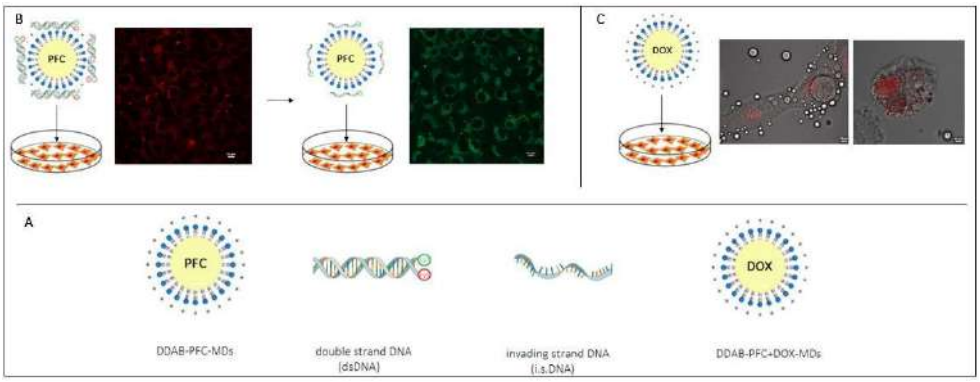

Figure 1. Section A shows the legend of the illustrated figures. Section B illustrates the treatment of Sk-Mel 28 culture with DNA-MDs. In the first step, the transfection of dsDNA takes place while subsequently the transfection of i.s.DNA highlights the strand displacement reaction that took place in the cytosol. In section C the Sk-Mel 28 culture was treated with MDs containing Doxorubicin (DOX). From the images we can see the adhesion of DOX-MDs to the cell membrane, the release of the drug and the consequent cell death.

Keywords

Nanotechnology; ultrasound; MDs; melanoma; ADV; drug delivery; transfection.

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P.02 - Double shelled perfluorocarbon microdroplets as a versatile ultrasound phase-change platform

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Microdroplets (MDs) with a liquid perfluorocarbon (PFC) core can transform into microbubbles (MBs) when exposed to a proper ultrasound field through the processes known as Acoustic Droplet Vaporisation (ADV) [1]. The properties of the socalled "phase-change" ultrasound contrast agents rely on this process (Figure 1A, C). Thanks to the resonant acoustic response of the MBs formed after vaporisation, MDs can be considered suitable for enhancing the imaging contrast of pathological regions or even for tracking at high frame rate the dynamics in blood flows [2]. Furthermore, MDs may become promising theranostic agents due to their ability to conjugate the dramatically increased ultrasound echogenicity after vaporisation with the drug cargo capability [3]. Significant improvement in this respect mainly passes through the engineering of a shell conferring to the MDs a proper colloidal stability (even upon ADV), chemical versatility and size control [4]. Herein, we present micrometric decafluoropentane (DFP) MDs stabilized by a hybrid shell made up of a double biocompatible layer: the inner one made of dimethyldioctadecylammonium bromide (DDAB) cationic surfactant and an elastomeric external one of crosslinked dextran methacrylate (DexMa) (figure 1B). The high positive charge given by DDAB provides a stability, even to MDs encapsulated by the surfactant monolayer (DDAB MDs) only. It also enables the electrostatic decoration of the MDs with anionic gold nanoparticles (AuNPs), thus unlocking the possibility of optically improving the vaporisation efficiency. The long and saturated hydrocarbon chains of the DDAB shell stabilize the droplet and the drug cargo therein while the DexMa shell allows to obtain stable cavitating MBs upon ADV. Summing up, we obtain a stable and versatile multimodal "phase-change" contrast agent (DDAB+DexMa MDs) which can also act as a drug and/or nanoparticles carrier with several in vitro applications.

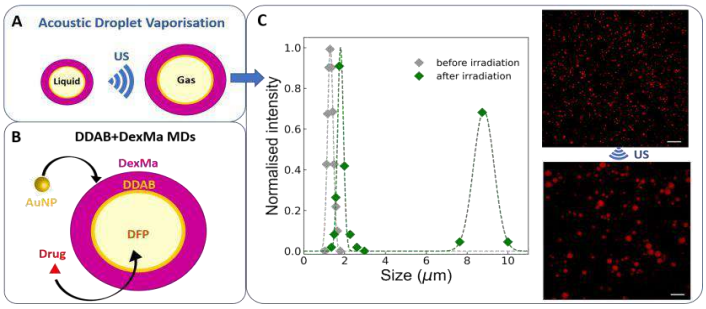

Figure 1. A) Sketch of the ADV process (A), and of versatile DDAB+DexMa MDs (B); dynamic light scattering diameter-intensity distributions and corresponding Gaussian best fits of DDAB+DexMA shelled MDs before (light grey) and after (green) acoustic irradiation and representative confocal laser scanning microscopy micrograph. The ADV process was induced by irradiating MDs for 5 minutes with an acoustic field of 0.5 W/cm^2 intensity at 37 °C. Scale bar is 10 μm.

Keywords

Ultrasound; Microdroplets; Acoustic Droplet Vaporisation; Phase change contrast agents.

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P 03 - High-energy ultrasound synthesis of Sonogel-Carbon material modified with bulk polyaniline. Application in the electrochemical sensing of model chlorophenols

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This work carries through the development of a Sonogel-Carbon material modified with polyaniline powder, included into the silicon oxide network, by high energy-ultrasound, reaching the ultrasonic cavitation and increasing the surface contact between alkoxide and water [1]. This work aims to obtain a conducting material with better electrochemical performance than the Sonogel-Carbon material, as reported in bibliography with other massive modifiers [2,3]. The resulting material was electrochemically evaluated by differential pulse voltammetry using 4-chloro-3-methylphenol as analyte, obtaining a sharp analytical signal with higher current peak in comparison with the unmodified sensor (see Figure 1).

The modified electrode material was electrochemically, texturally and structurally characterized using spectroscopic, microscopic and voltammetric techniques. It was also applied in several electrochemical studies in buffer and spiked water samples. Furthermore, the electrochemical detection of other chlorophenols of interest was achieved with the sensor, demonstrating its analytical usefulness. Therefore, a well-known synthesis process assisted by high-energy ultrasound can be easily modified, providing materials with better electrochemical features in comparison with the unmodified ones.

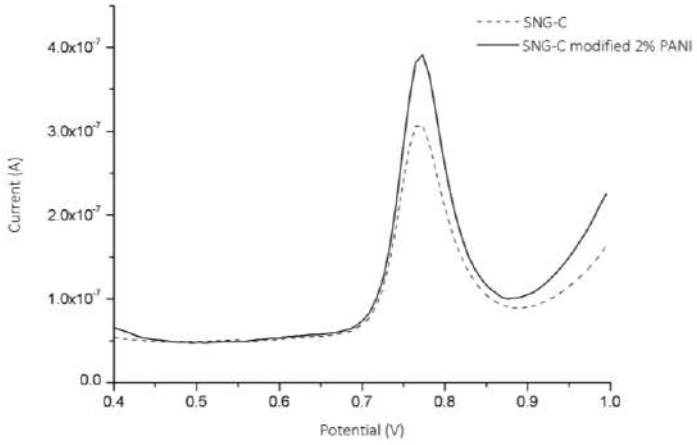

Figure 2. *Differential pulse voltammograms recorded with the Sonogel-Carbon sensor modified with PANI and the unmodified one in the same 4-chloro-3-methylphenol solution. Electrolytic medium: 0.1 M acetic/acetate buffer solution at pH 4 with 0.5 M KCl.*

Keywords: Sonogel-Carbon; Polyaniline; Differential pulse voltammetry; Chlorophenol; Spiked water

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P 04 - Novel ceramic carbon black-polyaniline material synthesized by high-energy ultrasound with anti-fouling properties in electrochemical sensing

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In the past few decades, a large number of ceramic materials synthesized through sol-gel route and assisted by high-energy ultrasound have been developed [1]. One common problem of these materials in electrochemical sensing applications is the surface fouling, more usual in the determination of analytes which involves polymerization processes followed by radical coupling, like chlorophenols. The solution to this drawback arises in the inclusion of several redox mediators into the silicon oxide network [2]. Based on this, high-energy ultrasound assisted synthesis of a bulk material based on Sonogel-Carbon and polyaniline, in its conducting form, modified with carbon black was performed. Carbon black, employed in this work as massive modifier, is a nanoallotrope of carbon with a high specific surface and electric conductivity, which contribute to its performance as an electrocatalyst [3]. Its proportion in the material was optimized, showing the modified sensor a better response towards a probe analyte than the one provided by bare Sonogel-Carbon-polyaniline sensor. The most interesting feature of this novel sensor was the prevention of fouling problems during the detection of 4-chloro-3-methylphenol (PCMC) in acid buffer solution, in contrast with the drawback observed with the bare sensor (see Figure 1). Hence, the modification of the material with carbon black led to remarkable electroanalytical features towards PCMC. Furthermore, the developed sensor was used in several electrochemical assays, including the analysis of spiked water samples with great recovery values.

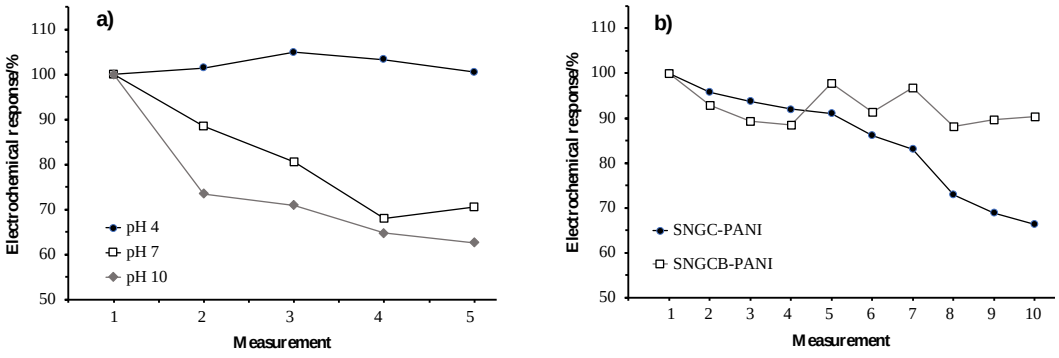

Figure 1. *Electrochemical response of a Sonogel-Carbon Black-PANI electrode towards PCMC during successive measurements in different buffer solutions (a) and response of a Sonogel-Carbon Black-PANI electrode and Sonogel-Carbon-PANI electrode towards PCMC during successive measurements in pH 4 buffer solution (b), recorded with Differential Pulse Voltammmetry.*

Keywords: Ultrasound; Electroanalysis; Conducting polymer; Nanomaterial; Anti-fouling properties

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P 05 - Ultrasonic pretreatment of vegetal material to increase the extraction yield of bioactive compounds

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Abstract

Nowadays natural products isolated from plant seem to be effective as medicinal agent against various disorders[1]. Thyme (*Thymus officinalis* L) is an aromatic plant which contains essential oils, that are the most valued component of this herb. The main constituents of thyme essential oil (EO) are thymol and its isomer carvacol that have shown immunomodulatory, antioxidant, antiinflamatory, antibacterial and antifungal properties[2][3]. The aim of this study was to establish the effect of ultrasonic pretreatment of thyme leaves on the EO extraction content and on the amount of main constituents from thyme EO. The extraction of EOs from thyme was carried out using hydrodistillation technique. Prior to the ultrasonic pretreatment, the influence of different parameters (heating type and plant to solvent ratio) on the extraction efficiency was studied. The best results were achieved for the microwave hydrodistillation method and a plant/solvent ratio = 1/12 (w/v). The ultrasonic pretreatment has been performed using two ultrasoound equipmwent (an ultrasonic bath and an ultrasound probe Vibracell VCX750). A significant increase in EO content (from 1.7 to 2.1 g/100g dry matter (DM)) was obtained for ultrasonic pretreatment with ultrasound probe Vibracell VCX750. The results are shown in figure 1. Regarding the chemical composition, the thymol content of ultrasound pretreated thyme leaves was higher than the unpretreated ones.

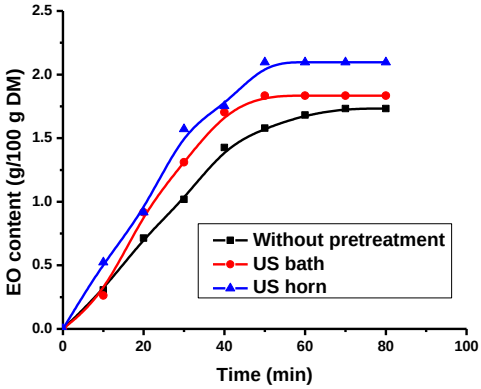

Figure 1. *The effect of the ultrasonic pretreatment of thyme leaves on the EO extraction by microwave assisted hidrodistillation*

Keywords: Essential oil extraction, Thyme; Ultrasound pretreatment, Thymol, Microwave hidrodistillation

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P 06 - Influence of ultrasound on the release of levonorgestrel from a hormonal intrauterine device Mirena

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Abstract

Mirena is a hormonal intrauterine device, or IUD, that can be used for long-term birth control and to treat heavy periods. Mirena birth control works by releasing levonorgestrel. Levonorgestrel is a progestogen used in a variety of contraceptive products. Low doses of levonorgestrel can be administered into the uterine cavity with the Mirena intrauterine delivery system. Initially, levonorgestrel is released at a rate of approximately 20 μg/day. This rate decreases progressively to half that value after 5 years. Ultrasonography plays an essential role in evaluating IUD position and assessing for complications [1,2].

The aim of this study was to investigate whether the frequent use of ultrasound to control Mirena's position could influence on the increased release of levonorgestrel from a hormonal intrauterine device Mirena.

In order to check whether ultrasound had an effect on increased hormone release from IUD Mirena the following experiment was performed. To simulate the real situation of placing Mirena into the uterine cavity in woman's body, we placed a new Mirena in a 50 mL plastic container and added 0.9% saline solution. Each container had an acoustic window made of thin plastic film, onto which we placed an ultrasonic transducer over the gel. As ultrasound source, we used NPL's continuous-wave checksource which operates at a fixed frequency of 3.5 MHz [3]. The device has three switchable settings, allowing nominal powers of 10 mW, 100 mW and 1 W to be applied. The NPL Checksource essentially covers the diagnostic and low therapy power range. We exposure to ultrasound waves 11 samples (containers with Mirena and saline solutions). We varied the exposure time from 1 min to 30 min and we varied applied ultrasound power. After exposure to ultrasound, Mirene were removed from the containers and saline samples were analysed by Liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS) to quantify levonorgestrel.

The results of our measurements showed that ultrasound did not have a statistically significant effect on the increased release of levonorgestrel from a hormonal intrauterine device Mirena.

Ultrasound; hormonal intrauterine device; Levonorgestrel; ultrasound effect;

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P 07 - Acoustically Induced Acceleration of Iron Migration in Silicon Solar Cells

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Abstract

It is well known that ultrasound (US) can effectively interact with defects in semiconductors. It was experimentally observed that US can cause atomic diffusion[1], transformation of native and impurity defects[2], and annealing of radiation defects[3]. Most acoustically induced (AI) changes in crystal defect subsystem are residual, but reversible AI phenomena are occur as well. The aim of our work is to investigate experimentally the FeB pair association in silicon solar cells under US loading conditions. The n^+-p-p^+-Si structure was fabricated from a 2 in. (380 μm thick) p-type boron doped Czochralski silicon wafer with a resistivity of 10 Ω·cm. The FeB pair dissociation was made by flash illumination. The short circuit current (I_{SC}) under monochromatic light was used to characterize recombination process in the solar cell base. The iron atom migration energy (E_m) was extracted from I_{SC} kinetic after FeB pair dissociation. In the case of US loading, the longitudinal acoustic waves with the frequency of 4.1 MHz, which were excited by using a piezoelectric transducer, were applied to the samples at the base side. The investigation has revealed an acoustically driven reversible decrease in the iron migration energy. The E_m alteration value non-linearly depends on US intensity (see Fig.1) and diminishes with temperature decrease. In our opinion, the observed effect is induced by the displacement of impurity atoms with respect to their surroundings. Thus the ultrasound can be effective defect engineering tool in silicon.

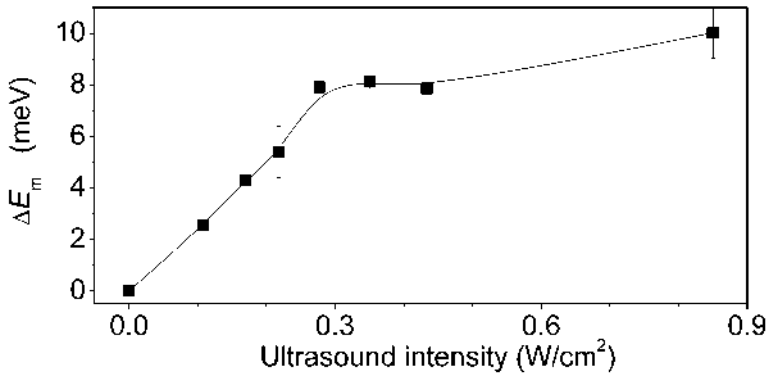

Figure 1. Dependences of iron migration energy change on US intensity. Temperature of US loading is 340 K.

Keywords

Ultrasound loading; Silicon; Fe-B pair dissociation; Acousto-defect interaction; Reversible effect

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P 08 - The influence of ultrasound on the properties of oil-dispersed systems

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Abstract

At the present time, the effect of the ultrasonic field on the properties of oil-dispersed systems (ODS) is being actively investigated. Successful theoretical and experimental studies in the field of ultrasonic cavitation and acoustic currents made it possible to develop new technological processes. Ultrasonic treatment (UST) is one of the most environmentally friendly methods of treatment of ODS, but the pattern of changes in rheological and energy characteristics after UST depends on the component composition of the system and parameters of treatment. It is clearly seen that the effect of ultrasound on highly paraffinic dispersed systems leads to an increase in such macrocharacteristics as shear stress, viscosity, and energy parameters. On the other hand, in the presence of polymer depressants, the negative effect of acoustic impact on highly paraffinic systems is neutralized and their viscosity-temperature characteristics are improved [1].Evaluating the effectiveness of the integrated method to reduce the viscosity of highly paraffinic crude oils can be simplified by using model systems, in particular petroleum wax (PW) solution.

Therefore, this study is focused on the effects of silica-gel resins (SR) on the structural and mechanical properties of a 6 % wt PW solution in n-decane (PW-d) treated with ultrasound. Besides the effect of exposure to ultrasound alone and sonication with subsequent introduction of crude oil with high resin content (crude oil-2) on the properties of highly paraffinic crude oil (crude oil-1) is considered.

We treated the samples in ultrasonic field (frequency 22 kHz, radiation intensity 18 W/cm^2, exposure time 10 min). In the followed case we added petroleum resins (0.3 % wt) or crude oil-2 to the treated sample (PW-d or crude oil-1) to prove that our resins are natural viscosity depressants and sedimentation inhibitors.

Our results clearly indicate that Ultrasonic treatment of ODS stimulates the crystallization of paraffin. This leads to an increase in viscosity, pour point and the amount of paraffin deposited. The introduction of SR or crude oil-2 into the sonicated ODS improves the viscosity-temperature characteristics, reduces the specific energy of degradation of the supramolecular structure, and positively affects the mass and the structure of sediments (Figure 1). Significant inhibition of the process of sedimentation and improvement of the viscosity-temperature properties is observed when even 10 % wt of resinous crude oil is added to sonicated paraffinic crude oil.

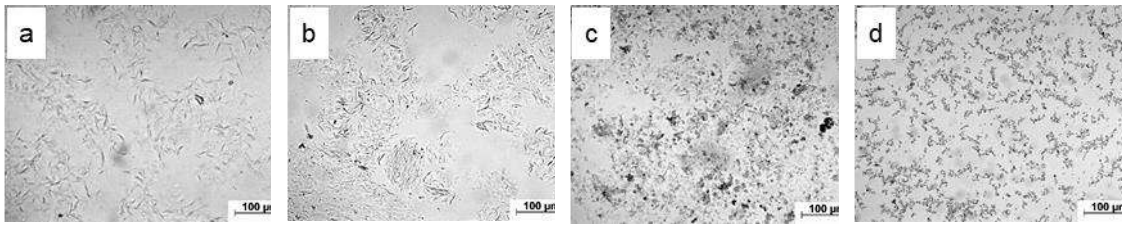

Figure 1. The crystal structures micrographs of the sediments: a – crude oil-1; b – 10 min; c – 10 min + 3 % wt crude oil-2; d – 10 min + 10 wt % crude oil-2.

The results of our work indicate that mixing oils with various compositions in combination with ultrasonic treatment could be used for the transportation of highly paraffinic feedstocks through pipelines at low temperatures.

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P 09 - The influence of ultrasound on the efficiency of the vacuum impregnation and selected characteristics of the plant material

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Abstract

Vacuum impregnation is a two-stage process. In the first, the so-called vacuum stage, the raw material is placed in a solution of the desired compound, then the pressure is reduced and native fluids located in porous space are removed. In the second, the so-called relaxation stage, the pressure is restored to atmospheric conditions and the open pores/capillaries of the material are filled – impregnated, with the solution [1]. The effectiveness of the VI may be affected both by the internal (material structure and porosity) and external resistances (e.g. laminar boundary layer). The use of ultrasound during VI is aimed at reducing both types of resistance, e.g. by loosening the internal structure, increasing porosity or reducing the thickness of the laminar boundary layer.

The aim of this work was to analyse the influence of ultrasound on the effectiveness of the vacuum impregnation process of plant materials such as potatoes and carrots. Vacuum impregnation process was performed with a pressure of 50 mbar or 300 mbar in vacuum stage. The isotonic impregnation solution consisted of ascorbic acid, citric acid (both 0.5%) and sucrose. Ultrasounds were applied during the different stage of VI processes (UVI1 - vacuum stage, UVI2 – relaxation stage, UVI3 - whole process, UVI4 - atmospheric pressure restoration stage). Additionally, the selected quality parameters of the material were analysed (colour, water activity, ion leakage). It was found that ultrasound positively influenced the effectiveness of VI. Samples processed with the ultrasound enhancement (UVI1-UVI4) were characterized by a higher ascorbic acid content, compared to unsupported VI processes (Fig. 1). However, the qualitative effect depended on the stage in which the ultrasound was applied. The best effects were observed for the processes with continuous support (UVI-3) regardless of the pressure applied. There were also no negative effects of ultrasound on the analysed quality parameters.

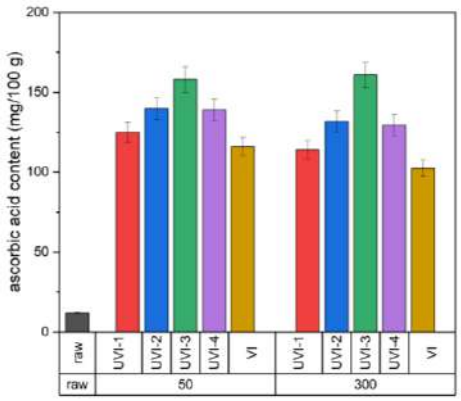

Figure 1. *The ascorbic acid content of potatoes after impregnation at different pressure conditions: 50 and 300 mbar.*

Keywords

functional food; acoustic cavitation; intensification of mass transfer; colour; food

References

[1] A. Derossi, T. De, C. Severini, In Scientific, Health and Social Aspects of the Food Industry, 1st ed.; Valdez, B., Ed.; IntechOpen Limited: London, UK, 2012.

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