

ABSTRACT BOOK

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Future Materials 2025

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Plenary Talks

Chemical Patterning of Graphene and Inorganic 2D-Materials

Andreas Hirsch*

Department of Chemistry, University of Erlangen, Erlangen, Germany

Abstract:

Chemical functionalization of new C-allotropes such as the 2D-graphene is of fundamental interest and opens the door to unprecedented materials applications. We will report on the development of efficient functionalization protocols for graphene using both covalent and non-covalent approaches. In particular, the reductive functionalization of graphene allows for the attachment of a variety of functional systems such as porphyrines and fullerenes to the basal plane. A fundamental challenge of graphene functionalization is the spatially resolved covalent patterning of this 2D-system. We will also emphasize our recent success in this direction. We have demonstrated that both mask assisted patterning of graphene and laser writing can be used and even be combined to generate hierarchically ordered multifunctional 2D-architectures. The potential of practical applications is enormous. This includes chemical information storage exemplified by complete write/read/erase cycles. Moreover, we will present our recent on the chemical functionalization of other 2D-materials such as particular black phosphorus (BP) and MoS₂.

Biography:

Andreas Hirsch received his Ph.D. in 1990 from the University of Tübingen. From 1990 to 1991 he was a postdoctoral fellow at the Institute for Polymers and Organic Solids in Santa Barbara, California in the group of Prof. Wudl. He subsequently returned to Tübingen as a research associate at the Institute for Organic Chemistry. Since October 1995, he has been chaired Full Professor of Organic Chemistry at the University of Erlangen-Nürnberg. In 2010 he received an ERC Advanced Grant. In 2017 he became an elected member of the “Bayerische Akademie der Wissenschaften” and received a second ERC Advanced Grant.

Nanotechnology-Enabled Energy Efficiency Electronics

Bingqing Wei^{1*}, and Zhigang Li²

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Abstract:

The semiconductor industry consumes staggering amounts of electricity annually, surpassing the energy usage of over 100 nations. This immense consumption not only underscores the environmental impact but also generates substantial heat within semiconductor devices, adversely affecting their performance, lifespan, and reliability, posing significant challenges to the advancement of nanodevices. To address these challenges, reducing energy consumption through the use of advanced, energy-efficient technologies has become a priority. Energy-efficient electronics (EEE), enabled by nanotechnology, hold the potential to drastically cut the energy usage of semiconductor devices while simultaneously enhancing their performance. From this perspective, this discussion focuses on super-

semiconductors poised to advance EEs: plasmon-induced metal-based semiconductors that show potentials to EEs.

Biography:

Dr. Bingqing Wei is the George W. Laird Professor of Mechanical Engineering and serves as Director of the Center for Fuel Cells and Batteries at the University of Delaware, USA. He is the inaugural Field-Chief-Editor of *Frontiers in Nanotechnology*. Dr. Wei was an Assistant Professor in the Department of Electrical & Computer Engineering and Center for Computation & Technology at Louisiana State University 2003-2007. He was a Research Scientist at Rensselaer Polytechnic Institute, Department of Materials Science and Engineering, and Rensselaer Nanotechnology Center 2000-2003. 1993-2001, he was a faculty member at Tsinghua University in Beijing.

Keynote Talks

Advancing Tissue Engineering and Regenerative Medicine: The Role of New Materials and Bioprinting Technologies in Next-Generation Therapeutic Applications

Daniel Nieto^{1,2}

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²*Opportunius. Axencia Galega de Innovación, 15702, Santiago de Compostela, Spain*

Abstract:

The field of therapeutic delivery, tissue engineering, and regenerative medicine is on the cusp of transformation, driven by the development of innovative materials and cutting-edge technologies. In this talk, we will explore the critical role of new materials in advancing therapeutic and investigative delivery systems, with a particular focus on bioinspired and biomimetic designs that replicate the properties and functionalities of natural tissues. These materials are vital for enabling precision medicine, improving the effectiveness of drug delivery systems, and providing new solutions for tissue regeneration and repair.

A significant emphasis will be placed on the role of smart biomaterials and advanced bioprinting technologies, with a special focus on light-based bioprinting tools that enable the creation of highly detailed, three-dimensional tissue constructs. These tools are revolutionizing our ability to fabricate complex tissue architectures, paving the way for the development of functional tissues for research, transplantation, and regenerative therapies. However, challenges remain in achieving the precision and resolution necessary for creating viable tissues that mimic the complexity of native biological systems.

To address these limitations, this talk will introduce the novel concept of holographic optical tweezers, a cutting-edge technology capable of manipulating individual cells and biological materials at the microscale with extreme precision. By combining holographic optical tweezers with light-based bioprinting, we can overcome many of the current barriers in bioprinting, such as material fidelity and resolution, and achieve more accurate, reproducible tissue structures. This integration holds tremendous potential for improving the functionality of bioprinted tissues, advancing regenerative medicine, and opening new avenues for personalized therapeutic applications.

Biography:

Daniel Nieto García is an Oportunius Professor and Distinguished Researcher (ERC Consolidator Fellow) at the University of La Coruña, where he leads the Advanced Biofabrication Laboratory. He is also an extraordinary professor at North-West University in South Africa, where he is leading the DNIETO satellite lab focused on overcoming fundamental questions in living tissue biofabrication. His research aims to address the current challenges in bioprinting to enable the creation of functional organs. He was awarded the ERC Consolidator grant to develop HOTB bioprinting technology. He has been visiting professor at prestigious institutions, including Harvard, MIT, and Oxford, has authored 80 publications, and holds 7 patents. He is also the co-founder and CSO of two bioprinting companies.

Autonomous Electrochemical Sensing

M. Goreti F. Sales

Abstract:

The great success of glucose meters is the public symbol of biosensing, about which there is still room to evolve. The possibility of reducing their basic requirements (especially their dependence on electricity and electronics) and expanding their current scope would be a millennium game changer in biosensing. First, an autonomous electrical power supply could support electrical autonomy. This could be achieved by fusing biosensing technology (i) and a renewable energy source (ii) into a single device that generates energy in a concentration dependent manner. The elimination/reduction of electronics can also be achieved by coupling an electrochromic cell (iii) that produces a color signal visible to the naked eye as a function of current intensity. Finally, the application of this combined approach requires the use of biorecognition elements, which are responsible for defining the target compound that controls the operation of the system. In practical terms, (i) the biosensor is a biomimetic plastic antibody tailored to a cancer biomarker and acts as one of the electrodes of the photovoltaic cell or fuel cell; (ii) the photovoltaic/fuel cell acts as an electrical reader of the biosensor with a concentration-dependent electrical output; (iii) the electrochromic cell receives the electrical output of the biosensor/photovoltaic cell, which in turn results in a concentration-dependent colour change. This innovative approach was successfully tested on various cancer biomarkers (as carcinoembryonic antigen, CEA, or sarcosine), being currently under development in the course of the SensoPAD European-funded project.

Overall, these innovative and groundbreaking approaches have proven successful and are under development, opening doors to a whole new concept of biosensing that can be applied in all areas where biosensing becomes necessary, even when common energy sources are missing.

Acknowledgements: The SENSOPAD project has received funding from the European Union's Horizon Europe Research and Innovation Programme under grant agreement n° 101130516.

Biography:

Goreti Sales is a full professor in the Department of Chemical Engineering at the Faculty of Science and Technology of the University of Coimbra and coordinates the BioMark Sensor Research group. She holds a degree in Pharmaceutical Sciences (1994), a PhD in Analytical Chemistry (2000) and Habilitation in Chemical Engineering (2017). Her research interests focus on nanomaterials, technology and biosensors. She received a Starting Grant from the European Research Council in 2012 for the fusion of biosensors and solar cells and has coordinated other EU-funded projects supported by the Future and Emerging Technologies of the European Innovation Council (e.g. MindGAP).

Design and Development of TTF- and M-BDT-Based Molecular Conductors

Dulce Belo*, I.C.Santos, E.B.Lopes, M.Almeida, and S.Rabaca

Instituto Superior Técnico, Lisboa, Portugal

Abstract:

Molecular conductors based on π -conjugated systems have attracted considerable interest due to their potential in organic electronics. Among the most promising molecular components are

tetrathiofulvalenes (TTFs) and transition metal bisdithiolates (M-BDTs), both valued for their tunable electronic properties and structural adaptability. TTFs are well known as π -donor molecules capable of forming stable radical cations, while M-BDTs act as π -acceptors, offering additional electronic degrees of freedom through metal-ligand interactions. Both classes typically consist of planar molecules with comparable HOMO–LUMO energy levels, enabling complementary electronic behavior. This work presents recent developments in the design, synthesis, and characterization of molecular conductors based on TTF and M-BDT frameworks. Special attention is given to their behaviour in two-dimensional bilayer conductor systems ^[1] and as Single Component Molecular Metals (SCMM) ^[2], highlighting their relevance for the development of novel functional molecular materials.

Biography:

Dulce Belo (PhD in Chemistry from IST, 2002) is a principal researcher at DECN@IST. As an experimental chemist, she has dedicated her career to the design, synthesis, and physical characterization of molecular conductors and magnets, including single-component molecular conductors, making key contributions to the field of molecular electronics. Beyond her research, and since 2013, she is also a guest lecturer at the Department of Chemical Engineering of IST, having been distinguished, annually, with the IST teaching excellence award.

Synthetic Extracellular Matrix Analogues: Driving Tissue Regeneration through Highly-Tuned Control of Bioligand Presentation to the Cells**Matteo Santin**

Centre for Regenerative Medicine and Devices, School of Applied Sciences, University of Brighton, Huxley Building Lewes Road Brighton BN2 4GJ, United Kingdom

Abstract:

The processes of tissue remodelling and regeneration are orchestrated by complex cell activities and are controlled through bio-signalling pathways among which the biospecific interactions of cells with the components of the extracellular matrix (ECM) play a fundamental role.

The break-ups of these interactions, as caused by pathological conditions or traumas, cannot always be spontaneously restored and medical intervention, through either implants or a regenerative medicine approach, is required.

Both in the case of the '*re-placement*' of a damaged tissue by an implant or its complete '*re-generation*' by tissue engineering or cell therapy approaches, the control of the healing processes is required. In the former case, the successful integration of an implant is determined by the formation of a healthy tissue in direct contact with the artificial surface of the device as opposed to that of a fibrotic capsule walling the implant off from the host tissue. In the latter case, tissue regeneration needs to be guided by supporting tissue cells in their processes of proliferation, differentiation and synthesis of new ECM.

To fulfil either implant integration or whole tissue regeneration, materials able to mimic the ECM have been investigated, mainly aiming at the simulation of the physicochemical properties of tissues.

More recently, biomimicry (or biomimetics) has been explored at biomolecular level by the synthesis of biomaterials exposing specific amino acid sequences known to be present in proteins of the ECM and responsible for controlling cell adhesion and intracellular pathways key to tissue regeneration.

This talk will provide a critical overview of the different solutions proposed by this approach demonstrating how the spatial- and density-controlled presentation of these synthetic bioligands is fundamental to the organisation of cells into tissue-resembling structures and, ultimately, to a physiological regeneration of damaged tissues.

Biography:

Matteo Santin is the Director of the Centre for Regenerative Medicine and Devices at the University of Brighton, where he is also a Professor of Tissue Regeneration. His research focuses on regenerative medicine, particularly the development of natural and synthetic biomaterials for bone and cartilage regeneration, cardiovascular devices, and neurodegenerative diseases. He holds two PhDs, one in Biomaterials from the University of Naples and another in Biomedical Sciences from the University of Brighton, and has extensive experience in the field, with over 80 published papers and 9 patents.

Advances in Materials and Technology for Volumetric 3D Printing

Christophe Moser

Laboratory of Applied Photonics Devices, IEM Institute, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland

Abstract:

3D printing has transformed the fabrication of volumetric components and structures across numerous fields. The advent of photocurable viscous resins has enabled the development of fully volumetric, light-based printing techniques, achieving remarkable print speeds—as fast as a few tens of seconds for centimeter-scale constructs—while maintaining high resolution at approximately 40 microns. This review will explore a variety of materials, both organic and inorganic, processed using tomographic volumetric printers. We will present examples of intricate 3D objects, ranging from inorganic materials such as ceramics, polymers, and glass to organic materials like hydrogels, including tissue models such as bone, liver, and pancreatic cancer tissues.

Volumetric printing relies on homogeneous and relatively transparent resins to prevent the scrambling of light patterns during photopolymerization. We will introduce a novel method that compensates for light scattering, enabling the fabrication of complex structures using opaque and composite resins.

Biography:

Christophe Moser started his career as an engineer at Hexagon Metrology in Switzerland after graduating from EPFL in physics in 1993. He obtained his doctorate degree in 2000 in optical information processing from the California Institute of Technology (Caltech). Christophe co-founded and was the CEO of Ondax, Inc. (acquired by Coherent) in Monrovia, California. In 2010, Christophe joined EPFL. He is now full professor and the Director of the MicroEngineering Section. His current research topics include light based volumetric additive manufacturing to reach micrometer resolution at the centimeter scale in different materials whose properties range from very soft - hydrogels to very hard - ceramics, glass. He has also research activities in endoscopic imaging and neuromorphic computing.

Electroactive Framework Materials for Energy Storage: Dual Proton-Electron Conductors and Organic Electrodes for Rechargeable Batteries

Manuel Souto^{1,2}

¹*CiQUS, Centro Singular de Investigación en Química Biolóxica e Materiais Moleculares, Departamento de Química-Física, Universidade de Santiago de Compostela, 15782, Santiago de Compostela, Spain*

²*CICECO Institute of Materials, Department of Chemistry, University of Aveiro, 3810-393, Aveiro, Portugal*

Abstract:

Energy storage devices that are based on earth-abundant elements, environmentally friendly, and possess high energy density are essential for storing electricity generated from renewable sources. Conventional cathodes based on transition metal oxides need to be replaced to reduce reliance on critical raw materials such as cobalt. Redox-active metal-organic (MOFs) and covalent organic frameworks (COFs) have emerged in recent years as auspicious electrode materials for energy storage applications due to their high stability, porosity to facilitate ion diffusion, and huge chemical and structural versatility. Besides their inherent porosity, MOFs and COFs may also incorporate electronic functionalities such as electrical conductivity, becoming attractive for their implementation as components in different devices. In this direction, the development of mixed ionic-electronic conductors is of great interest for energy storage applications. In the first part of the talk, I will present one of the first examples of a proton-electron dual-conductive MOF based on tetrathiafulvalene (TTF)-phosphonate linkers. In the second part of the talk, I will present some examples of organic electrode materials based on redox-active COFs used as high-capacity organic cathodes in Li and Mg batteries. Finally, the synthesis and electrochemical properties of a series of redox-active TTF-based COFs that were explored as high-voltage organic cathodes for lithium batteries will be presented.

Biography:

Manuel Souto Salom (Valencia, 1988) is an Oportunius Research Professor and Principal Investigator at CiQUS - University of Santiago de Compostela. He is also a Guest Professor at the University of Aveiro. His current research interest is the design and synthesis of new functional electroactive framework materials (e.g., COFs & MOFs) based on redox-active organic building blocks for energy storage applications. In 2021, he was awarded an ERC Starting Grant with the project ELECTROCOFS, which aims to design a new generation of redox-active COF electrodes for rechargeable batteries. He received, among other distinctions, the Young Researcher Award by the RSEQ (Group Leader Category). He is Fellow of the Young Academies of Europe (YAE) and Spain (AJdE).

Polypeptide-Based Therapeutics: Exploring Tropism and Overcoming Biological Barriers

María J. Vicent*, Maria Medel*, Esther Martínez, Amina Benaicha, Snežana Đorđević, and Inmaculada Conejos-Sanchez

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Abstract:

Synthetic polypeptide-based nanomedicines offer a versatile and advanced therapeutic platform, with examples such as Vivagel® and Copaxone™ already achieving market approval. Imaging plays a crucial role in optimizing nanomedicine-based therapies by improving patient stratification and accelerating the development of personalized treatments. Theranostics, which combines therapeutic and diagnostic functions into a single agent, allows real-time monitoring and addresses key challenges in nanomedicine. Porphyrins and phthalocyanines, organic compounds with favorable photophysical

properties, are widely used in diagnostic imaging and photodynamic therapy due to their strong absorption and emission characteristics.

In this study, we developed biodegradable polypeptide-based nanostructures using N-carboxy anhydride ring-opening polymerization (NCA-ROP). We synthesized four-armed polyglutamic acid (PGA) constructs that self-assemble into stable supramolecular nanostructures with therapeutic potential. By incorporating porphyrins and phthalocyanines as a core, these nanostructures exhibit intrinsic imaging properties, making them suitable for both diagnostic and therapeutic applications. The removal of protecting groups was achieved without racemization, leading to structures with different shapes, from cylindrical to spherical, depending on the number of PGA units. These nanostructures demonstrate varying circulation times and cell accumulation profiles, making them highly adaptable for imaging and photodynamic therapy. Biological evaluation has confirmed their robust potential for imaging applications and therapeutic efficacy, highlighting their promise in advancing the field of nanomedicine.

Biography:

María J. Vicent is head of the Polymer Therapeutics Lab at the Príncipe Felipe Research Center (CIPF), where she also coordinates the Cancer Program and serves as Scientific Director since 2023. She is president-elect of the Controlled Release Society (CRS) and editor-in-chief of *Advanced Drug Delivery Reviews*. Her research focuses on developing nanopharmaceuticals for unmet clinical needs, supported by national and European grants like the ERC Consolidator and ERC PoC grant or La Caixa projects. A recognized innovator, María holds 15 patents, co-authored 150+ papers, and co-founded Polypeptide Therapeutic Solutions S.L., now Curapath, a leading CDMO company.

Serendipity Sometimes Works

José L. Vilas^{*1,2}, Leire Ruiz^{1,2}, Leyre Perez^{1,2}, A. Catarina Lopes, and Maria I. Moreno^{1,2}

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²*BCMaterials, Basque Center for Materials, Applications and Nanostructures, UPV/EHU Science Park, 48940 Leioa, Spain*

Abstract:

Some time ago, we began a project involving the synthesis and use of inorganic nanoparticles. Over time, nanoparticles evolved from their inorganic nature to a more organic one, obviously modifying their properties. While the common thread remains size, the chemical composition and end use of the materials range from magnetic properties to environmental remediation. This talk aims to show an example of how nanotechnology has become useful at the industrial level, despite appearances to the contrary, taking advantage of the synergy between almost all areas of science: chemistry, physics, geology, and biology.

Biography:

Dr. José Luis Vilas Vilela is a Professor in the Department of Physical Chemistry at the University of the Basque Country. He has held various management positions in companies and research centers. His research activity has focused on polymeric materials. In recent years, he has focused his research on active polymeric materials and advanced 3D and 4D manufacturing, as well as on improving their sustainability. He has participated in more than 80 research projects and has supervised more than 25 doctoral theses, published 11 book chapters, and more than 300 research articles.

Development of Self-Healing Aluminium Alloys

Maria Cecilia Poletti^{1,*}, Marlene Eichlseder¹, Anika Wiebogen¹, Talina Terrazas Monje¹, Elisabetta Gariboldi², Ilse Letofsky-Papst³, and Antonio Mattia Grande⁴

¹*Institute of Materials Science, Joining and Forming / Graz University of Technology, Graz, Austria*

²*Mechanical Engineering Department / Politecnico di Milano, Milan, Italy*

³*Institute of Electron Microscopy and Nanoanalysis, Center for Electron Microscopy / Graz University of Technology, Graz, Austria*

⁴*Department of Aerospace Engineering/ Politecnico di Milano. Milan, Italy*

Abstract:

Like some other alloys, aluminium alloys exhibit the potential for self-healing their damage either during or after service. Unlike high-performance concrete and plastics, this property is not frequently utilised, primarily because the conditions necessary for self-healing are difficult to identify. Products that can self-heal their damage could render aluminium production significantly more sustainable. Here, we investigate the self-healing characteristics of Al-Cu and Al-Si alloys due to the diffusion of alloying elements that repair damage during or after service through heat treatments and electrical currents. We produce several chemical compositions using laser powder bed fusion of pure aluminium and pure alloying elements via an in-situ alloying method. This method creates local gradients of chemical compositions and supersaturated conditions that promote the diffusion of the alloying elements. The processing parameters govern the formation of various intermetallic phases with distinct morphologies. These microstructures are characterised using metallography. Subsequently, we analyse the damage and self-healing of the produced and heat-treated materials exposed to creep conditions following different experimental protocols, including Dynamic Mechanical Analysis (DMA) testing. We compare the performance of the printed alloys with that of conventional ones. The results indicate that the alloying element diffuses into the pores if the alloying elements are allowed to diffuse freely. Specifically, in the case of Cu, this occurs in both the as-produced material and the solid solution heat-treated condition. Secondary Si can also diffuse within the pores and repair them. Our initial results demonstrate the potential of specific aluminium-based systems to heal during or after service.

Biography:

Maria Cecilia Poletti studied chemical engineering at UNComa, Argentina. She finished her doctoral studies on titanium alloys in 2005 in Austria at the TU Wien. She worked as a university assistant and joined TUGraz in 2011 as a tenure-track professor at the Institute of Materials Science, Joining and Forming. In 2013, as the Modelling and Simulation group leader and deputy head of the institute, she focused on applied and fundamental research in solid-state and additive manufacturing of metallic materials. Her research aims to understand physical phenomena in alloys processing, including solidification, plastic deformation, and phase transformation. From 2017 to 2025, she led the Christian Doppler Laboratory for high-performance alloy design through thermomechanical processing.

Building Human Organs with Butterfly, Graphene and Stem Cell

Alexander M. Seifalian

Abstract:

We are developing human organs using 3D scaffolds in combination with stem cell technology. In recent years, smart nanomaterials have shown tremendous potential in repairing and replacing damaged tissues, significantly advancing the field of regenerative medicine.

A pivotal moment came in 2010 when UK-based scientists isolated a single layer of carbon atoms. Since then, graphene has been regarded as a "wonder material" due to its exceptional properties: it is 100 times stronger than steel, highly elastic, and an excellent conductor of electricity.

Our research focuses on functionalized graphene oxide (FGO) and polyhedral oligomeric silsesquioxane (POSS), inspired by the nanostructures found in butterfly wings. We have developed a nanocomposite material from these substances, which serves as a 3D scaffold. When combined with growth factors, peptides, and stem cells, it facilitates the repair and replacement of damaged organs.

In this presentation, I will highlight our work on the development of cardiovascular devices, facial organ reconstruction, and drug delivery systems.

In conclusion, graphene- and POSS-based nanocomposites offer groundbreaking opportunities to meet unmet clinical needs through the creation of functional human organs and next-generation medical devices.

Biography:

Alexander Seifalian, Professor of Nanotechnology and Regenerative Medicine worked at the Royal Free Hospital and UCL for over 26 years, during this time he spent a year at Harvard Medical School working on development of vascular compliance graft and one year at Johns Hopkins Medical School looking at the treatment of liver cancer. He published more than 787 peer-reviewed papers and registered 14 UK and International patents. He supervised 121 PhD students, all successfully completed. He is currently director of Nanotechnology & Regenerative Medicine Commercialization Centre (NRMCC), and co-founder of NanoRegMed Ltd, Nanoloom Ltd and Liberum Health Ltd) working on the commercialization of his research.

Advancing Safety and Innovation: OECD WPMN's Role in Nanomaterials and Advanced Materials

Mar Gonzalez, OECD, France

Symposium I: Future Biomaterials-Biomedical, Medicine and Other Applications

Featured Presentations

Photoactive Nanostructured Coordination Polymers as Novel Materials for Cancer Therapy

Fernando Novio^{1*}, Daniel Ruiz Molina², Junda Zhang², Claudio Roscini², Sebastian Tanco³, Pau Sarles³, and Julia Lorenzo³

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Abstract:

Light-activated nanoparticles offer a promising avenue for targeted cancer therapy. Upon exposure to light, specific nanoparticles can release reactive oxygen species (photodynamic therapy)^[1] or induce the release of an anticancer drug (photoactivated chemotherapy)^[2], both of which can selectively kill cancer cells. This approach allows for precise targeting of tumors, minimizing damage to healthy tissue and potentially enhancing the effectiveness of cancer treatment.

We propose different families of nanostructured coordination polymers for light induced therapies. On the one hand, nanoparticles containing photosensitizers such as porphyrins of iridium complexes able to induce the production of ROS. On the other hand, nanoparticles bearing Ru-active complexes as constitutive building blocks and a photocleavable bridging ligand as an example of PACT applications^[3]. Precise control of the reaction conditions led to the reproducible synthesis of narrow size distribution for the nanoparticles with remarkable reproducibility and chemical composition control. The photoactivation of the resulting nanoparticles was studied in solution and in cellular cultures. In vitro studies demonstrated the potentiality of these nanosystems to be used as new materials for PDT and PACT.

In a proof-of-concept study, these nanoparticles emerge as promising materials with potential application in cancer therapy. Higher intracellular uptakes of nanoparticles were observed in vitro compared to molecular compounds, and an increase in effectiveness occurs over a long period of time with reduced systematic toxicity. Results gathered in these works open a future path for investigation of photoactivable nanoparticles for cancer treatment.

References:

1. G. Li, C. Wang, B. Jin, T. Sun, K. Sun, S. Wang, Z. Fan, *Cell Death Discovery* 2024, 10, 466.
2. H. Lu, S. He, Q. Zhang, X. Li, Z. Xie, Z. Wang, Y. Qi, Y. Huang., *Biomater. Sci.*, 2021, 9, 7115-7123.
3. J. Zhang, V. Ramu, X-Q. Zhou, C. Frias, D. Ruiz-Molina, S. Bonnet, C. Roscini, F. Novio *Nanomaterials* 2021, 11, 3089.

Biography:

Dr. Fernando Novio graduated in Chemistry from the University of Santiago de Compostela (USC). He obtained his PhD in chemistry (2007) at the Autonomous University of Barcelona (UAB). Then he moved to the Laboratoire de Chimie de Coordination (LCC) in Toulouse (France) for his postdoctoral stage (2008-2010), and from 2011 to 2021 he joined the Catalan Institute of Nanoscience and Nanotechnology (ICN2), as Senior Researcher. From 2022 he is Associate Professor in the Chemistry Department at UAB.

His research subject is related principally to the technological and biomedical application of coordination polymer nanoparticles and other polymer-based nanoformulations.

Multifunctional Nanotubes for X-Ray Activated Photodynamic Therapy (X-PDT)

Valeria Secchi*, Irene Villa, and Angelo Monguzzi

University of Milano Bicocca, Italy

Abstract:

Multicomponent nanomaterials consisting of dense scintillating particles functionalized by optically active conjugated photosensitizer (PS) for cytotoxic reactive oxygen species have been proposed in the last decade as coadjuvant agents for radiotherapy of cancer, in order to sensitize the production of cytotoxic singlet oxygen (SO) in the biological environment and therefore inducing cells death through oxidative damage of cellular membranes. We present the results obtained by employing as nanoscintillator, synthetic chrysotile nanotubes (NTs) in their highly biocompatible stoichiometric form, which can be easily prepared in aqueous solution under hydrothermal conditions. The outer surface of NTs is brucitic and in aqueous environment is modified by concentrating Mg^{2+} ions towards the surface, giving rise to a positive Z-potential. This property allows to bind to the surface a number of anionic chemical species, including anionic PS. The obtained nanomaterials have been successfully tested as X-PDT agent^[1]. The results of the in vitro tests indicate that the functionalized NTs, thanks to increased energy release given by their interaction with high-energy radiation and to the sensitized production of cytotoxic SO, help to both (i) promptly kill the tumorigenic cells by boosting the thermal shock and (ii) limit their reproduction by favouring the triggering of the apoptosis mechanism^[2].

References:

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2. I. Villa, C. Villa, R. Crapanzano, V. Secchi, M. Tawfilas, E. Trombetta, L. Porretti, A. Brambilla, M. Campione, Y. Torrente, A. Vedda, A. Monguzzi, *ACS Applied Materials & Interfaces*, 2021, 13 (11), 12997-13000

Biography:

Valeria Secchi is an Assistant Professor at the Department of Materials Science at the University of Milano-Bicocca in Italy. Her research focused on the development of nanomaterials for biomedical applications in the framework of several national and international projects and networks. In particular, her current research is mainly based on the chemical synthesis, functionalization and characterization of multicomponent and luminescent hybrid nanoparticles and nanotubes for applications in radiotherapy (RT), X-ray induced photodynamic therapy (X-PDT), multimodal imaging and drug delivery.

Controlled Release of the Anticancer Drug Cyclophosphamide from a Superparamagnetic β -Cyclodextrin Nanosponge by Local Hyperthermia Generated by an Alternating Magnetic Field

Sebastián Salazar Sandoval^{*1}, Patricia Díaz-Saldívar², Ingrid Araya³, Freddy Celis⁴, Diego Cortés-Arriagada⁵, Ana Riveros^{6,7}, Carlos Rojas-Romo⁸, Carolina Jullian¹, Nataly Silva⁹, Nicolás Yutronic⁸, Marcelo J. Kogan^{6,7}, and Paul Jara⁸

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Abstract:

A β -cyclodextrin (β -CD) nanosponge (NS) was synthesized using diphenyl carbonate (DPC) as a cross-linker to encapsulate the antitumor drug cyclophosphamide (CYC), thus obtaining the NSs-CYC system. The formulation was then associated with magnetite nanoparticles (MNPs) to develop the MNPs-NSs-CYC ternary system. The above-mentioned formulations were characterized to confirm the deposition of the MNPs onto the organic matrix and that the superparamagnetic nature of the MNPs was preserved upon association. The association of the MNPs with the NSs-drug complex was confirmed through field emission scanning electron microscopy, energy dispersive spectroscopy, transmission electron microscopy, X-ray photoelectron spectroscopy, dynamic light scattering, ζ -potential, atomic absorption spectroscopy, X-ray powder diffraction, selected area electron diffraction, and vibrating-sample magnetometer. The superparamagnetic properties of the ternary system allowed the release of CYC utilizing magnetic hyperthermia upon the exposition of an alternating magnetic field (AMF). The drug release experiments were carried out at different frequencies and intensities of the magnetic field, complying with the "Atkinson-Brezovich criterion." The assays in AMF showed the feasibility of release by controlling hyperthermia of the drug, finding that the most efficient conditions were $F = 280$ kHz, $H = 15$ mT, and a concentration of MNPs of 5 mg/mL. CYC release was temperature-dependent, facilitated by local heat generation through magnetic hyperthermia. This phenomenon was confirmed through DFT calculations. Furthermore, the ternary systems outperformed the formulations without MNPs regarding the amount of released drug. The MTS assays demonstrated that including CYC within the magnetic NS cavities reduced the effects on mitochondrial activity compared to that observed with the free drug. Finally, the magnetic hyperthermia assays showed that the tertiary system allows the generation of apoptosis in HeLa cells, demonstrating that the MNPs embedded maintain their properties to generate hyperthermia. These results suggest that using NSs associated with MNPs could be a potential technology for controlled drug delivery in tumor therapy since the materials are efficient and non-toxic.

Biography:

Sebastián Salazar Sandoval is an Environmental Chemist and a PhD in Chemistry, graduated from the Faculty of Chemical and Pharmaceutical Sciences, University of Chile. He is now a FONDECYT postdoctoral fellow at the Faculty of Chemical and Pharmaceutical Sciences, University of Chile. His

research is dedicated to designing and optimizing synthetic processes related to gold, silver, magnetite, and copper materials, whether as nanoparticles or nanocomposites, and their potential applications in drug delivery and wastewater remediation systems. Further, his primary expertise comprises synthesizing and characterizing cyclodextrin nanosponges for their potential applications in the removal of organic pollutants and in drug delivery formulations.

Dual Role of *Nerium oleander* L.: Investigating its Potential for Heavy Metal Remediation and Colorectal Cancer Treatment

Naira Ibrahim^{1*}, Felicite Noubissi², Hung-Chung Huang³, Oluwatoyin V. Odubanjo⁴, and Xavier Smith⁵

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Abstract:

Colorectal cancer (CRC) remains a major health concern, with the Wnt/ β -catenin signaling pathway playing a pivotal role in its progression. This study explores the anti-proliferative effects of *Nerium oleander* L. on CRC cells, hypothesizing that it inhibits cell growth by downregulating the Wnt signaling pathway. Additionally, we aim to identify genes that link heavy metal remediation ability with anti-cancer properties. CRC cells will be treated with extracts from both control and lead (Pb)-treated plants at concentrations of 100 ppm and 500 ppm to determine differential effects on cellular responses. Preliminary findings suggest that *Nerium oleander* L. suppresses the Wnt signaling pathway, exhibits antioxidant activity, and inhibits CRC cell proliferation in a dose-dependent manner. Future work will focus on identifying key genes involved in both heavy metal detoxification and cancer inhibition, optimizing extract concentration, performing apoptosis assays, and fractionating the extract to isolate active compounds. This research provides novel insights into the dual potential of *Nerium oleander* L. for environmental bioremediation and cancer treatment.

Biography:

Dr. Naira A. Ibrahim is an Assistant Professor of Environmental Science and Plant Biology at Jackson State University, where she has been a faculty member since 2021. She holds a Ph.D. from the Environmental Institute Research of El-Sadat University, Egypt, and completed postdoctoral studies at Tuskegee University. Dr. Ibrahim's research focuses on phytoremediation and the environmental impacts of heavy metals, with a particular emphasis on understanding the genetic basis of heavy metal uptake and tolerance in plants. She has secured significant funding for her work, and has published extensively on bioaccumulation and phytoremediation. He is an active member of professional organizations such as the Natural Areas Association and the American Geophysical Union. Additionally, she serves as a reviewer for papers on phytoremediation and has contributed to a book chapter on uranium phytoremediation. Dr. Ibrahim has presented her research at national and regional conferences and has co-authored multiple papers on the subject. She also assists in teaching computerized modeling techniques related to environmental sciences, including the HYSPLIT model and other Microsoft Excel-based models. Her work blends rigorous scientific research with practical applications, contributing to both environmental science and the development of the next generation of scientists.

Reference and New Approach Methodologies in the Evaluation of New (Nano) Materials in the Safe and Sustainable by Design Framework: The INTEGRANO Project Experience

M. Gualtieri, R.D. Bengalli, S. Cervellera, S. Marchetti, F. Deganello, and P. Mantecca

University of Milano - Bicocca, Italy

Abstract:

The possibility of developing new (nano)materials without determining unwanted hazard on potentially exposed humans and environment is of paramount importance for those applications that require high amounts of the novel product or a continuous innovation to find more sustainable solutions.

In this context, the European Commission in 2022 supported the adoption of the Safe and Sustainable by Design (SSbD) framework which was recently updated. The main goals of the framework are to promote green and sustainable innovation in production processes; to replace or to reduce the use of possible hazardous materials; to minimize the potential negative impacts on human and environmental health.

Among the different approaches proposed to tackle the characterization of the hazardous effects on humans, the SSbD framework pinpoint to the application or development of new approach methodologies (NAMs). In this context, the INTEGRANO project, funded by the European Union (GA No 101138414) aims at evaluating the potential hazardous effects of novel (nano)materials by building on consecutive steps of toxicological relevance and complexity of the tested models. Here we report on the toxicological evaluation of novel materials (such as Perovskite nanoparticles produced according to different designs of experiment) starting from classical submerged conditions. The further steps expected in the testing the new materials according to a NAM already developed are proposed.

The main pros and cons of classical approaches and NAM are discussed also with reference to the SSbD framework.

Biography:

Maurizio Gualtieri is an Associate Professor at the University of Milano-Bicocca, Italy. His research focuses on environmental toxicology, with a particular emphasis on the health impacts of airborne particulate matter and advanced in vitro lung models. Over the years, he has contributed extensively to understanding the mechanisms of particle-induced oxidative stress, inflammation, and DNA damage. Dr. Gualtieri has authored numerous peer-reviewed publications and is actively involved in national and international research collaborations aimed at improving air-quality risk assessment and public health protection.

Simplified Life Cycle Assessment of Nanoenabled Products in Early Design Phases: Application to the Additive Manufacturing Sector

Leire Barruetabeña

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Abstract:

Life Cycle Assessment (LCA) is a pivotal tool for developing sustainable materials and products, providing essential environmental insights that help align industrial innovation with growing sustainability demands. Its role is widely recognized in European policy frameworks, where it is considered a foundational method for assessing environmental performance and informing sustainability-related decisions. Within this context, LCA is central to the Safe and Sustainable-by-Design (SSbD) approach, complementing chemical hazard assessment, risk analysis, and socio-economic evaluation to support the development of safer, more sustainable solutions.

Despite its strengths, applying LCA to emerging technologies still presents key challenges -particularly the lack of reliable data during the life cycle inventory phase. This issue is especially critical when assessing novel materials and processes in early design stages, such as those involved in additive manufacturing and nanomaterial development, where standardized datasets and validated information remain limited. In the case of nanomaterials, additional complexity arises from uncertainties around their environmental release and the scarcity of characterization factors needed to assess impacts on human toxicity and ecotoxicity.

In response, recent efforts have focused on strategies to overcome these limitations, including the development of nano-specific characterization factors and sector-adapted LCA tools. The SAbYNA project, funded by the European Union's Horizon 2020 program, contributes to this goal by offering tools to facilitate simplified LCA in early design phases, with a sector-specific perspective.

As part of this initiative, a dedicated tool has been developed for the additive manufacturing sector. It enables scenario-based evaluations using a streamlined LCA approach that incorporates default values—drawn from proxy, representative, and secondary data—to model both nano-specific characteristics and sector-specific aspects. The tool supports iterative assessment by identifying key parameters that may require refinement, enabling alignment with the evolving definition of products and processes.

Biography:

Researcher in the Environmental Management Area at GAIKER, with over 25 years of experience in the Recycling and Circular Economy Department. She has extensive expertise in applying Life Cycle Assessment (LCA) to support the evaluation and selection of clean materials and technologies for the development of sustainable products. In recent years, her work has focused on applying LCA methodology in the context of the Safe and Sustainable by Design (SSbD) framework. She has actively collaborated with public institutions, industry stakeholders, and associations to adapt and promote the use of LCA and related tools across various sectors.

Safety Assessment of Advanced Nanomaterials. Challenges and Gaps

Blanca Suarez-Merino

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Abstract:

The landscape of advanced nanomaterials is very dynamic, with novel materials being constantly developed to address societal challenges. However, from a regulatory perspective, it is becoming a real challenge to monitor the current situation and update regulatory needs accordingly, to ensure that

innovative products are safe. Even if the sectors in which advanced nanomaterials are being used are diverse, approaches to address safety are generally based on a set of internationally agreed guidelines, guidance or standards. International programs such as the one launched by the OECD in 2007 have paved the way to the adaptation of testing guidelines and guidance to nanomaterials, ISO/TC 229 and CEN/TC 352 Nanotechnologies have also implemented working groups to develop relevant standards. All these efforts have allowed a good understanding of the shortcomings of earlier approaches developed for chemicals and how, in some instances, those can be adapted to nanomaterials. This presentation will provide an overview of where we are regarding safety assessment of complex, advanced nanomaterials, gaps identified and current initiatives to advance in the field.

Biography:

Dr. Blanca Suarez Merino is a toxicologist with over 15 years' experience in safety assessment of chemicals including nanomaterials in different sectors (chemicals, cosmetics, medical devices, and food contact materials). Dr Suarez-Merino was part of the coordination team under the Safegraph SH11 (Graphene Flagship). She is a national expert under the Nanotechnologies Standardization Group through the Swiss Association for Standardisation (SNV), an expert of the Swiss National Platform on the safe handling of synthetic nanomaterials and has contributed to the development of the Precautionary Matrix for Nanomaterials, as well as to testing guidelines for safety assessment of nanomaterials, the latest one being the adaptation of OECD Guideline 442D. Dr Suarez-Merino is very active in EU initiatives focusing on the safety assessment of nanomaterials and advanced materials, is author to several publications on nanosafety and actively contributes to the topic in conferences and events.

Safety Evaluation of Two-Dimensional Nanomaterials: Overcoming Challenges in Skin Sensitization Testing

Michela Carlin

Department of Life Sciences, University of Trieste, Trieste, Italy

Abstract:

Advanced two-dimensional nanomaterials (2DM), such as graphene, hexagonal boron nitride and black phosphorus, are attracting considerable attention in the scientific and industrial sectors given their outstanding physico-chemical properties. In detail, the boost in 2DM market size requires a careful evaluation of their impact on human health, acquiring robust and reliable data, also suitable for regulatory purposes. Considering the cutaneous contact as one of the most relevant 2DM exposure routes for humans, corrosion, irritation and sensitization are the most feasible adverse outcomes that could occur at the skin level.

In particular, this contribution focuses on skin sensitization with the aim to assess the possibility to adopt the three *in chemico/in vitro* Test Guidelines (TGs) defined by the Organization for Economic Cooperation and Development (442C, D and E) to predict the first three phases of skin sensitization Adverse Outcome Pathway (peptide reactivity, keratinocytes activation and dendritic cells differentiation, respectively). Being originally validated for chemicals, the possibility to adopt them for 2DM was evaluated, focusing on graphene-based materials (GBMs), as reference 2DM. TG 442C resulted not suitable for testing GBMs due to their reactivity, leading to possible misclassifications. By contrast, TG 442D and E can generally be applied for GBMs. However, protocol adjustments were required to reduce interferences with cell

viability assessment for TG 442D, and to select the optimal doses on the basis of GBM dispersion stability for TG 442E. When applying these modifications, GBMs resulted unable to activate keratinocytes and promote dendritic cells differentiation, so they can be considered non-sensitizers.

Overall, these results significantly contribute to characterize 2DM safety profiles and to improve testing methodologies to obtain reliable toxicological data.

Biography:

Michela Carlin is a post-doctoral researcher at the University of Trieste (Italy), specializing in toxicology. With a PhD in Environmental Life Sciences, her research is focused on the human health impact of two-dimensional nanomaterials, with particular emphasis on assessing and mitigating their potential skin toxicities.

Environmental Nanosafety of 2D-Nanomaterials: A Case Study on the Sexual Reproduction of Seed Plants

Fabio Candotto Carniel^{1*}, Nida Zaib^{1*}, Wendalina Tigani¹, Andrea Bogo², Enrico Boccato¹, and Mauro Tretiach¹

¹*University of Trieste, Department of Life Sciences, Trieste, Italy*

²*University of Trieste, Department of Chemical and Pharmaceutical Sciences, Trieste, Italy*

Abstract:

The increasing use of two-dimensional nanomaterials (2DNMs) in consumer products raises concerns about their release into the environment and their safety. While airborne graphene oxide (GO) has been shown to affect plant reproduction, the effects of other 2DNMs are still largely unknown. Given their light weight, planar structure, and dispersal potential, our aim was to investigate the effects of 2DNMs on sexual reproduction of wind- and animal-pollinated plants.

We investigated the effects of GO, hexagonal boron nitride, molybdenum disulphide, and muscovite mica in three economically important species: *Cannabis sativa* L. (hemp), *Corylus avellana* L. (common hazel) and *Cucumis sativum* L. (cucumber – GO only). The flowers were exposed to 2DNMs by aerosol (gravity-driven and direct spray) and brush application. Time-dependent effects of 2DNMs on the stigma surface and internalization into stigma tissues were examined by E-SEM and TEM. Artificial pollination was performed to evaluate potential impacts on pollen germination and fertilization.

2DNMs adhered to the stigma surfaces of all species without causing visible damage. Neither penetration of 2DNMs in the intercellular spaces nor internalization into cells was observed. Pollen germination decreased significantly over time in hemp and hazel flowers exposed to 2DNMs with a minimum of ~42% in hemp after 24 h as compared to controls. Effects on fruit and seed development in cucumber will be discussed.

Our study shows that the three engineered 2DNMs can affect the pollen-stigma system even after a short exposure time at environmentally relevant concentrations. However, their effects on pollen–stigma interactions are comparable to those of mica, a naturally occurring 2DNM. Considering these findings and the increasing use of 2DNMs in everyday products, there is an urgent need to deepen the

investigation of their potential toxicity to plant sexual reproduction—a fundamental biological process with critical implications for ecological, social, and economic systems.

Biography:

Dr. Fabio Candotto Carniel is a botanist at the University of Trieste with over ten years of experience studying the environmental safety and fate of graphene-based materials. His research focuses on their effects on plants and their biodegradability through ligninolytic and saprotrophic fungi.

This work began within *Work Package 4 – Health and Environment* of the **Graphene Flagship Core 1, 2, and 3** projects (EU Horizon 2020 programme), and has since continued with support from national grants funded by the **Italian Ministry of University and Research**, further contributing to our understanding of the ecological impact of advanced nanomaterials.

Nanomaterial-Based Smart Inks for Electrochemical Sensors

Alessandro Silvestri

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Abstract:

From their origins as a simple black pigment, carbon inks have played a foundational role in transmitting human knowledge. Today, the advent of graphene and 2D materials has ushered in a new era of smart inks, offering functionalities far exceeding traditional color.^[1] Integrating these advanced inks with modern printing technologies is now revolutionizing flexible electronics, as well as wearable and implantable sensors and actuators.

This presentation will detail strategies, including chemical functionalization, self-assembly, and phase engineering, for developing graphene and 2D material-based inks highly responsive to specific chemical concentrations.^[2,3] Our work specifically aims to create multifunctional inks capable of fulfilling every aspect of an electrochemical sensor: from bioreceptor immobilization and stabilization, through analyte recognition and transduction, to signal amplification.^[2,3] Ultimately, these smart inks enable the fabrication of entirely inkjet-printed electrochemical paper analytic devices (e-PADs), providing a pathway to low-cost, sustainable, and reliable electroanalytical platforms.^[4]

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Biography:

Alessandro Silvestri received his Ph.D. in Chemistry at the University of Milan (Italy) in 2017. He was a postdoctoral researcher at the Max-Planck Institute of Colloids and Interfaces (Potsdam, Germany) and CIC biomaGUNE (San Sebastian, Spain). Since June 2023 he has been an Assistant Professor in Chemistry at Ca' Foscari University of Venice. His research interests comprise the synthesis and chemical functionalization of nanomaterials and their application in electrochemical biosensors.

Charge Density Modulation in Graphene FET Biosensors for Virus Detection via Chemical Modification

Davide Campagnol¹, Virginia Cendán¹, Miguel Cuerva¹, Alba Centeno², Amaia Zurutuza², Jesus Mosquera¹, and Alejandro Criado¹

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Abstract:

The emergence of new infectious diseases represents one of the critical global health challenges for the next decade with the potential to strain healthcare systems worldwide, as demonstrated by the COVID-19 pandemic. In 2021, COVID-19 ranked among the top 10 causes of death globally, according to the WHO^[1]. The rapid spread of the SARS-CoV-2 highlighted the vulnerabilities of existing diagnostic infrastructures and highlighted the urgent need for faster, more sensitive, and widely accessible virus detection methods. Therefore, early and accurate virus detection is essential not only for timely medical intervention but also for controlling outbreaks, reducing transmission, and mitigating the socio-economic impact of pandemics.

To address this challenge, new generation of biosensors are being developed to push the limits of detection and advance the concepts of Point-of-Care Testing (POCT) and Lab-on-a-Chip technologies. In this context, graphene emerges as an ideal nanomaterial for biosensor designing, offering tunable electrical properties, biocompatibility, ease of functionalization, and potential for miniaturization^[2]. Despite these advantages, graphene-based biosensors have yet to replace established diagnostic techniques such as qPCR and ELISA, largely due to challenges in achieving high specificity and reproducibility.

In this study, we present a liquid-gated field-effect transistor (FET) biosensor for label-free detection of SARS-CoV-2 based on chemically modified graphene. Our approach enhances selectivity and minimizes non-specific interactions through a novel non-covalent functionalization strategy. By precisely tuning the graphene-liquid interface using tailored polymers and peptide moieties, we improve detection accuracy and reliability. These findings demonstrate the potential of graphene-based biosensors to provide rapid, sensitive, and portable diagnostic solutions, paving the way for next-generation tools in infectious disease detection.

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Biography:

Davide Campagnol is a passionate scientist active in the field of biosensing. He earned a degree in Medical Biotechnology from University of Trieste in 2013 and later completed a PhD in Science and technology of bio and nanomaterials at Ca’Foscari University in 2022. Combining his expertise in surface interactions between hybrid bio-nanomaterials, he focuses on developing innovative sensors, pushing

the boundaries of sensing performance, and exploring the potential of emerging nanomaterials. When he is not immersed in the wonderful world of sensors you will find him running across the world.

Bio-LLPS Engineering

Tomohiro Nobeyama

Graduate School of biostudies, Kyoto University, Japan

Abstract:

The reaction field plays a key role in the sophisticated behavior of living cells. Its modulation would be a critical method to control cell behavior and leads to the fine-tuning of synthetic biology or therapeutic applications. In this talk, I introduced the liquid-liquid phase separation (LLPS) of biomaterial, one of the driving forces of the formation/deformation of reaction fields, and the state-of-the-art methodology to control such reaction fields. These reaction fields are classified in terms of their dimension, two-dimensional LLPS reaction fields on lipid bilayer and three-dimensional reaction fields in liquids such as cytosol. I would like to introduce some nanobiodevices for each dimensional reaction fields.

Biography:

T. Nobeyama was given a degree of Ph.D. in 2020 and had worked in Tsukuba University as a scholar of Research Fellowships for Young Scientists PD. Currently, he works as a program-specific researcher at Kyoto University, Japan. His research interest consistently focused on reaction field modulation and fundamental characteristics of reaction field components such as molecular orbital level, size and/or shape of nanomaterial and so on.

3D *In Vitro* Model of Human Skin Wound Healing Using Phen Drive-Y as a Biomimetic Basement Membrane

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Abstract:

A fully established in vitro wound model is necessary for the precise recreation of wound healing processes, allowing for controlled, ethical, and reproducible research. It helps in the comprehension of cellular responses, testing of therapeutics, and recreation of acute or chronic states, decreasing the dependency on animal models and expediting drug discovery and treatment planning in wound care.

In this study, we aimed to develop a simple, stable 3D model of acute and chronic wounds on the basis of a co-culture model of HUVECs, fibroblasts, and inflammatory cells. The model was developed on a Phen drive-Y-coated tissue culture plastic surface for the closer proximity to 3D wound microenvironment.

A 24-well tissue culture plate was coated with Phenodrive-Y (1 vial in 10 mL of 75% ethanol). Each well was seeded with 60,000 HUVECs and 60,000 human fibroblasts in serum-free media and incubated for 48 hours at 37°C in a humidified atmosphere (95% O₂, 5% CO₂). After 3D model development was confirmed, a scratch assay was performed to simulate an acute wound. For the acute model, 100,000 U937 monocytes were added per well. For the chronic wound model, 100,000 U937 cells were added with 100 pg/mL IL-6 and 135 pg/mL TNF- α (Abcam, USA) to establish a chronic inflammatory environment. Cell migration via scratch assay was assessed after 24 hours of treatment. Angiogenesis, extracellular matrix (ECM) deposition, and macrophage polarization were assessed by immunostaining and cytochemistry assays to characterize the wound healing process. After 3 days of acute and chronic wound modeling, 1×1 cm pieces of N-A dressings were applied for 2 days to assess model stability and response to treatment. Migration, angiogenesis, macrophage polarisation, and extracellular matrix deposition were re-evaluated post-treatment by scratch assay, immunostaining, and cytochemistry techniques.

The co-culture of fibroblasts and HUVECs successfully formed a stable 3D structure with clear tubulogenesis, in favor of angiogenesis. In the acute wound model (U937 - inflammatory cytokines), there was ~80% migration with increased collagen deposition and preservation of angiogenic anastomosis junctions. A mixed M1 and M2 macrophage population was present. The chronic wound model (U937 + IL-6 + TNF- α) was <20% migratory with disruption of vascular junctions and an M1 macrophage predominant phenotype. After wound dressing application, healing was accelerated in the acute model, with migration and ECM deposition increased. Treatment in the chronic model induced a phenotypic switch towards M2 macrophages, resulting in improved collagen deposition and modest healing and angiogenesis improvement in migration.

This work describes a strong and durable 3D co-culture model of acute and chronic wound healing with HUVECs, fibroblasts, and inflammatory cells on Phenodrive-Y coated substrates. In comparison to classical matrices like Matrigel or collagen, this model is structurally more stable and has a longer culture time. It successfully recapitulates major phases of wound healing, including inflammation, proliferation, and remodeling.

Biography:

Dr. Shirin Saberianpour is a research fellow at the University of Brighton. She was awarded a PhD in Molecular Medicine on a full scholarship in 2019. Since then, she has accrued six years of research experience at various research centres, collaborating with different teams, from in vitro models to clinical trials. Her expertise primarily focuses on the cellular and molecular pathways involved in various diseases related to regeneration.

“Smart” Photoactive Theranostic Nanoplatforms for Precision Cancer Therapy

Ding-Kun Ji

Institute of Molecular Medicine /Shanghai Jiao Tong University, Shanghai, China

Abstract:

The efficient treatment of malignant tumors is a pressing global issue. However, traditional clinical treatment methods face challenges such as high drug toxicity, high recurrence rates, and multidrug resistance. Therefore, developing safe and efficient molecular targeted drugs is of great scientific and

clinical significance. The “Smart” photoactive theranostic nanoplatfroms offer advantages such as spatiotemporal controllability, non-invasiveness, and functional integration, providing numerous molecular tools for the precise diagnosis and treatment of malignant tumors. We focus on the precise design of novel, efficient, and safe “Smart” photoactive theranostic nanoplatfroms. Through molecular engineering strategies on different biomaterials, we have successfully prepared multifunctional molecular targeted nanoplatfroms that integrate molecular targeting, near-infrared light response, and in situ catalysis. We have developed new computer-assisted molecular simulation methods for systematically studying the structure-activity relationship of molecular targeted probes, improving the stability of probes and their binding affinity with target proteins. These molecular engineering strategies enable the precise loading and delivery of photosensitizers and chemotherapeutic drugs while significantly enhancing the water solubility and targeting performance of clinical hydrophobic drugs. We have also innovated the synergistic therapy of near-infrared photodynamic therapy, chemotherapy, and catalytic therapy, established a new mechanism for photodynamic enhanced tumor therapy, and provided essential research tools for the safe and efficient combined treatment of malignant tumors. Our aim is to establish new theoretical foundations for developing intelligent molecular-targeted drugs and advanced functional materials, while also inspiring innovative treatment strategies for malignant tumors.

Biography:

Dr. Dingkun Ji is an Associate Professor at Shanghai Jiao Tong University. His primary research focus is on medical biomaterials and molecular medicine. He is dedicated to designing and synthesizing multifunctional smart materials and molecular diagnostic probes using chemical methods to address clinical challenges. He has published more than 40 papers in international journals, including *Advanced Materials*, *Advanced Science*, *ACS Nano*, and *Nano Today*. Additionally, he has obtained 10 Chinese invention patents. As a project leader, he has successfully overseen 10 funding projects. He was selected for the "Shanghai Sailing Plan" and the "Overseas High-level Talent Introduction Plan" in Shanghai.

Mechanics Meets Light in Biomaterials: Novel MechanoOptical Biomarkers for Cancer and Pulmonary Fibrosis

Andreas Stylianou

European University Cyprus, EUC Research Centre, Nicosia, Cyprus

Abstract:

The nanomechanical properties of biomaterials like tissues and cells are increasingly recognized as critical indicators of disease progression and therapeutic response, particularly in non-communicable diseases (NCDs) such as cancer and pulmonary fibrosis (PF). In desmoplastic tumors (like sarcomas, breast and pancreatic cancer), tissue stiffening occurs alongside softening of malignant cells, creating significant barriers to effective drug delivery. Similarly, PF is characterized by stiffening of lung tissue due to excessive collagen deposition, yet lacks reliable, stage-specific biomarkers. This work introduces a novel class of *MechanoOptical Biomarkers*, integrating *Atomic Force Microscopy (AFM)* and *optical modalities* signatures (like fluorescence, Second Harmonic Generation (SHG) and currently Brillouin microscopy) to assess the mechanical and structural signatures of disease. Using AFM, we identified distinct nanomechanical fingerprints (NMFs) in human and murine tumor biopsies and PF models. These NMFs were sensitive to progression, responsive to treatment (e.g., anti-cancer treatment with doxorubicin and anti-fibrotic treatment with tranilast, , pirfenidone), and correlated with collagen I content and TME architecture. For cancer, AFM revealed measurable changes in tumor mechanics following microenvironment normalization, supporting the use of nanomechanical data as predictive

and monitoring biomarkers. In PF, NMFs reflected disease staging and treatment outcomes with high sensitivity, while machine learning demonstrated the possibility of using them as biomarkers. Coupling these mechanical insights with optical imaging enhances spatial resolution and contextual understanding, paving the way for *MechanoOptical Fingerprints (MOFPs)* as next-generation diagnostic tools. This approach aligns with the European Commission's strategic goals for NCD management by offering high-resolution, quantitative, and minimally invasive biomarkers. By bridging mechanics and light, we propose a paradigm shift in the diagnosis, monitoring, and personalization of treatments for cancer and PF—ushering in a new era of precision mechanopathology.

Biography:

Andreas Stylianou is an Associate Professor at European University Cyprus and Head of the Cancer Mechanobiology and Applied Biophysics Group. He holds two PhDs in Biophysics and Health Care Management. His research focuses on nanomechanical biomarkers, cancer mechanobiology, and optical imaging. He has published over 70 peer-reviewed articles and led numerous research projects with total funding exceeding €1.2 million. Dr. Stylianou has received multiple awards, including the Cyprus Research Award – Young Researcher, and has been listed among the world's top 2% most-cited researchers by Stanford University. He serves on editorial boards of several international scientific journals.

3D Printed Magnetic Scaffolds for Precise and Tunable On-Demand Drug Delivery

Elizabeth Rendon-Morales*, Chaolu Yan, and Rodrigo Aviles-Espinosa

Centre for Robotics and Sensing Technologies, School of Engineering and Informatics, University of Sussex, United Kingdom

Abstract:

Precision medicine aims to improve the patient's outcomes and minimize adverse effects by tailoring drug-based therapies to the individual characteristics. Magnetically actuated drug delivery systems enable non-invasive, targeted, and on-demand therapeutic release. However, important challenges in the design considerations, including the drug dosage volumes, total dosage incorporated in the design as well as the ability to batch manufacture such devices with high repeatability still require to be addressed. In this talk, we will explore the role of controlled drug delivery systems with a particular focus on magnetic field-responsive systems and the transformative impact of 3D printing technology. We use stereolithography 3D printing in combination with high-concentration magnetic composite UV curable resins for the fabrication of high-resolution, magnetically actuated drug delivery devices. By optimizing the 3D printing parameters we achieve structurally consistent and reproducible scaffolds with high geometric fidelity. Our results show that the scaffolds based on 40 w/w% magnetic micro-particles and photo-curable resin exhibit strong magnetic responsiveness, with low magnetic field strengths leading to compression ratios up to 52.94%, and drug release amounts ranging from $8.6 \pm 0.5 \mu\text{L}/\text{mm}$ to $135.9 \pm 3.1 \mu\text{L}/\text{mm}$. Comparative analysis of six scaffold designs reveals that structural configuration was used to tailor the drug release profile. The presented fabrication method and drug delivery devices are particularly suited for applications demanding accurate dose delivery and remote actuation. We present a proof-of-concept demonstration of our device for precise drug delivery in ophthalmic treatment.

Biography:

Dr. Elizabeth Rendon-Morales is an associate Professor in Engineering; Her current research is focused on the design and development of novel flexible sensors and actuators systems to contribute to the next

generation of on-demand drug delivery systems. She uses CAD design, computer simulations and additive manufacturing methods to design and test millimeter micro-porous magnetic triggered scaffolds. Low external magnetic field (< 300 mT) are used to control the level of compression and the superficial tension of the scaffold for the release of targeted drugs. She also works in designing CMOS sensors, machine vision systems and its integration in robotics for high precision applications in cardiac surgery.

Young Researchers Presentations

Harnessing the Dual Functionality of Carbon Nano-Onions: A Synergistic Approach to Light-Driven Biomedical Applications

Julia Requena-Ramírez¹, Matteo Andrea Lucherelli¹, Nolwenn Le Breton², Edison Castro^{3,4}, Luis Echegoyen^{3,5}, Silvye Choua², Jorge González¹, and Gonzalo Abellán¹

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Abstract:

Carbon nano-onions (CNOs) are concentric, graphitic carbon nanostructures that stand out for their high surface-to-volume ratio, stability, and excellent biocompatibility. These features have positioned them as promising candidates in biomedical research, particularly in areas like drug delivery, imaging, and cancer treatment.

In our work, we focus on exploring the potential of CNOs in photothermal (PTT) and photodynamic (PDT) therapies. When exposed to near-infrared light, CNOs exhibit efficient heat generation and can produce reactive oxygen species (ROS), opening the door to combined therapeutic approaches. The photothermal conversion efficiency observed was notably high, even when compared to other well-known carbon nanomaterials. At the same time, we confirmed their ability to generate ROS under irradiation, which adds an oxidative stress mechanism that can be harnessed in cancer therapy.

Building on these encouraging results, we are also working toward enhancing the targeting capabilities of these nanomaterials. To achieve this, we are developing strategies to graft DNA-based structures, such as aptamers, onto the surface of the CNOs. These oligonucleotides can recognize and bind specific biomarkers on cell membranes, potentially allowing for more selective accumulation of CNOs in diseased tissue while minimizing side effects on healthy cells.

Together, these efforts aim to establish CNOs as passive drug carriers and active, multifunctional platforms for next-generation cancer therapies. By combining efficient light-responsive behavior with molecular targeting, we envision CNOs as key components in future theragnostic systems—capable of diagnosing, treating, and monitoring disease in a single step.

Biography:

Julia Requena Ramírez is a PhD student in the Department of Inorganic Chemistry at the University of Valencia (Spain), under the supervision of Prof. Gonzalo Abellán and Prof. Jorge González García. She

holds a Bachelor's degree in Biotechnology from the University of Valencia, with a specialization in biomedical research, and a Master's degree in Molecular Nanoscience and Nanotechnology from the same university. Her research interests focus on the biomedical applications of carbon nanomaterials and their implementation in cancer therapy.

Hydrogel-Based 3D Printed Anthropomorphic Phantoms for Microwave Breast Imaging

Carlos M. Andreu^{1,2}, Daniel A. Sánchez-Bayuela³, and Ester Vázquez^{1,2}

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²*Instituto Regional de Investigación Científica Aplicada (IRICA) (UCLM), Ciudad Real, Spain*

³*ICADI Research Group, Hospital Universitario de Toledo, Toledo, Spain*

Abstract:

Microwave imaging (MI) is a promising, non-ionizing technique for early breast cancer detection. However, its clinical translation is limited by the lack of realistic breast phantoms that combine accurate dielectric properties with anatomical fidelity. Current models often fail to reproduce the dielectric contrast between healthy and malignant tissues, hindering validation and repeatability. This work presents a 3D-printed anthropomorphic breast phantom using hydrogel-based materials with tunable dielectric properties. Two hydrogels were developed: 2-hydroxyethyl acrylate (2-HEA) for healthy tissue simulation and methacrylated hyaluronic acid (HAMA) for tumour-mimicking inclusions. Both materials were characterized over the 0.5–9 GHz range, confirming their suitability for MI. Patient-derived MRI data were segmented to generate anatomical breast models, which were printed using 3D printing. The final bilayer phantom enabled reproducible tumour detection using the MammoWave system, thanks to the strong dielectric contrast. This approach offers a customizable and cost-effective platform for evaluating MI systems, bridging key material and anatomical limitations in current phantom design.

Biography:

Carlos Martín Andreu is currently in the fourth year of a Ph.D. at the University of Castilla-La Mancha (UCLM), specifically at IRICA. His research focuses on 3D printing of hydrogels and tissue engineering. His aim is to advance tissue engineering by utilizing hydrogels as bioinks for creating complex tissue constructs. His work emphasizes biocompatible hydrogel formulations.

Symposium II: Materials for Electronics, Optics and Photonics

Featured Presentations

Luminescence-Based Optical Sensors and their Integration into 3D-Printed Materials

Inocencio R. Martín^{1*}, Christian Hernández-Álvarez², Pablo I. Martín-Hernández³, Fernando Rivera-López³, Hanoch Hemmerich³, and S. Ríos¹

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Abstract:

Optical sensors work by sensing variations in the intensity, phase, polarization, wavelength, or spectral distribution of light as it interacts with the surrounding environment. Their light-based detection methods generally provide high efficiency. Additionally, they offer a key advantage over other detection systems, as they do not require direct physical contact with the object being examined.

In this work, different optical sensors based on luminescence from optically active ions were analyzed. On one hand, well-established Luminescence Intensity Ratio (LIR)-based systems are presented; on the other, Whispering Gallery Modes (WGM)-based systems using transparent microspheres are explored. Additionally, novel sensor structures fabricated through 3D printing technologies were developed and tested. These 3D-printed materials enable tailored geometries and functionalities, offering new possibilities for the integration of optical sensing elements.

Biography:

Dr. Inocencio R. Martín is Full Professor at the Department of Physics at the University of La Laguna, Spain. He obtained his PhD in 1996 from the University of La Laguna and is a member of the Laser Spectroscopy and High Pressure group. His research interests include the optical characterization of glasses, crystals and nanocrystalline glass-ceramics doped with optically active ions. He has over 290 publications in peer reviewed journals indexed in Journal Citation Reports and his research is focused in optical characterization of nanoparticles and microspheres doped with rare-earth ions and their applications.

Organic Semiconductors and Emitters for OLEDs and Optical Sensors

J.V. Grazulevicius*, V. Andruleviciene, O. Bezikonny, R. Keruckiene, K. Leitonas, J. Simokaitiene, E. Skuodis, U. Tsiko, and D. Volyniuk

Kaunas University of Technology, Kaunas, Country

Abstract:

Growing interest in recent decades is focused on organic glass-forming semiconductors. They are used as emitters and hosts in OLEDs, as charge transporting materials in organic and hybrid sol cells. Organic emitters exhibiting long-lived emission such as thermally activated delayed fluorescence or room-

temperature phosphorescence are recently widely studied as active materials of the different sensors. Organic semiconductors recently synthesized and studied at the laboratories of the author are reviewed. Compounds containing triphenylamine or 9-phenylcarbazole as donor moieties and pyrimidine-5-carbonitrile as electron-withdrawing unit were synthesized and studied. Pure blue and greenish-blue fluorescent OLEDs with external quantum efficiency (EQE) reaching 7% and 6%, correspondingly, were obtained using the newly synthesized compounds as emitters. EQE of more than 20% and the operation time exceeding 20000 h were recorded for OLEDs with pyrimidine-5-carbonitriles as the hosts. Sky-blue emitting derivatives of pyrimidine-5-carbonitrile and tert-butylcarbazole or methoxy carbazole showed good performance both as emitters of OLEDs and as active materials of oxygen sensors. Sky-blue OLED with EQE of 12.8% was fabricated using the newly synthesized emitter. The emitters were also used as oxygen probes. They showed fast response, high sensitivity and good stability. Very sensitive probes for detection of oxygen based on the derivative of triazatruxene and phenothiazine were developed. For 1% solid solution of the compound in Zeonex, the ratio of intensity of RTP observed under vacuum and fluorescence intensity recorded in air reached the value of 19. The derivatives of phenylethenyl-substituted phenoxazine and phenothiazine have appeared to be promising probes for the detection of explosive nitroaromatic compounds. The emission of the compounds exhibit extremely high sensitivity to electron-deficient picric acid via non-covalent interactions. Indolo[3,2-b]carbazole-based hole transporting materials were developed as hole transporting materials for dopant-free perovskite solar cells (PSCs). Power conversion efficiencies of the dopant-free PSCs of up to 19.45% was achieved.

Biography:

Dr. habil. Juozas Vidas Gražulevičius, Professor at the Department of Polymer Chemistry and Technology. His field of scientific interests comprise synthesis, studies of organic semiconductors and emitters and their applications in the devices of organic electronics. The special attention is currently paid to organic emitters and semiconductors for organic light emitting diodes, hole-transporting materials for perovskite solar cells, emitters exhibiting room-temperature phosphorescence for oxygen sensors. He has published more than 530 research papers in the international scientific journals, which were cited for more than 12400 times. His Hirsch index is of 53 (Google Scholar).

Plasmonic Nano-Coatings for Sensing Applications

Ribal Georges Sabat

Royal Military College of Canada, Kingston, Ontario, Canada

Abstract:

Custom optical fixtures were machined in-house and used to fabricate, in a single step photolithography technique, large-scale photonic nanostructures, which include quasicrystals and Moiré gratings on azobenzene molecular glass thin films. The obtained nanostructures or metasurfaces have customizable features depending on the fabrication parameters and the optical setup, which consists mostly of simple optical elements such as multi-faced pyramids, bi-convex lenses, Lloyd interferometer, and a continuous-wave laser for generating the desired interference pattern. Furthermore, these photonic metasurfaces have been used in applications ranging from optical biosensors to enhancing the efficiency of thin film solar cells. Furthermore, when coated with a layer of noble metal, they were used to excite surface plasmon resonance to create sensors, biosensors, retroreflectors and biomimicking nano-coatings found in nature.

Biography:

Prof. Sabat is a professor of physics and vice-principal academic at the Royal Military College of Canada. His research group has an expertise in optical materials, nanotechnology, and photonics. Their main

research thrust is on the laser fabrication of optical nanostructures, microstructures and metasurfaces in photomechanical azobenzene thin films. After fabrication, these films, having customizable surface features including biomimicry, exhibit interesting plasmonic and optical properties which are well-suited for incorporation in practical devices such as diffraction gratings, light-based sensors and biosensors, thin film solar cells, active optical coatings, selective spectroscopy surfaces and all types of imaging devices and applications.

Magneto-Photoresponse in 2D Optoelectronic Materials and Devices for Reconfigurable In-Sensor Vision Systems

Yuyan Wang^{1*}, Wenxuan Zhu², Jiacheng Sun¹, and Cheng Song²

¹*Beijing National Research Center for Information Science and Technology, Tsinghua University, Beijing, China*

²*School of Materials Science and Engineering, Tsinghua University, Beijing, China*

Abstract:

Machine vision systems have become a promising integral part of artificial intelligence applications. To reduce the hardware complexity, transmission latency, power consumption, while also improving performance in ambient environments, the architecture of in-sensor computing has been introduced. Correspondingly, the demand for reconfigurable optoelectronic devices has increased, primarily driven by mechanisms such as electrostatic doping or electric field induced by gate terminals. Herein, we experimentally demonstrate the reconfigurable 2D optoelectronic devices with photoresponse defined by the magnetization at room temperature. By combining the metallic electrodes of 2D ferromagnet Fe_3GaTe_2 with magneto-band structure effects and the photoelectric channel of WSe_2 , the photoresponse can be controlled by the direction and amplitude of magnetic fields, termed as magneto-photoresponse. Based on the reconfigurable optoelectronic device with magneto-photoresponse, the machine vision system with in-sensor self-adaptation is constructed, largely promoting the recognition accuracy in real-life extreme environments.

Furtherly, the nonvolatile magneto-photoresponse is achieved in 2D magnetic tunneling junctions with WSe_2 as the barrier layer, where the controllable photoresponse can be locally stored by the configuration of magnetizations. The architecture of in-sensor memory and computing for optical neural network is successfully fulfilled based on the nonvolatile magneto-photoresponse. Our work put forward an alternative strategy for the construction of reconfigurable optoelectronic devices. Benefiting from the robust and fast operation of magnetization, such optoelectronic devices with magneto-photoresponse are promising to advance in-sensor visions systems towards high stability and speed.

References:

1. Wenxuan Zhu, ...Yuyan Wang*, et al., *Advanced Materials*, 2024, 18, 2403624.
2. Wenxuan Zhu, ...Yuyan Wang*, et al., *ACS Nano*, 2024, 18, 27009.

Biography:

Yuyan Wang is an Associate Professor at Tsinghua University since 2020, specializing in spintronic and optoelectronic materials and devices. She earned her Ph.D. in Materials Science and Engineering at Tsinghua University in 2015, and served as an Assistant Professor at Beihang University from 2015 to 2020. In 2017, she was awarded the Humboldt Research Fellowship and conducted postdoctoral research at the University of Regensburg and Technical University of Munich in Germany until 2019. She has more than 60 publications, including papers in *Nat. Nanotechnol.*, *Nat. Electron.*, *Nat. Commun.*, *Sci. Adv.*, *Adv. Mater.*, *Phys. Rev. Lett.*, etc.

Regulation of Magnetic Structures and the Physical Properties in Antiperovskite Antiferromagnetic $\text{Mn}_3\text{XN(C)}$ Compounds

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²*School of Physics, Beihang University, Beijing 100191, China*

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Abstract:

Antiperovskite $\text{Mn}_3\text{XN(C)}$ compounds have rich magnetic structures and related physical properties, especially the non-collinear antiferromagnetic state and its "lattice-spin-charge" strong correlation characteristics have attracted more attention. In recent years, the research on spin regulation in Mn_3X (X: Ir, Pt, Sn, Ge, etc.) system has become a hot topic in the field of spintronic materials. With the discovery of abnormal Hall effect and spin Hall effect in Mn_3GaN , Mn_3SnN and relative materials, the regulation of the magnetic structures and their electronic transport properties in the antiperovskite Mn_3GaN and Mn_3GaC materials becomes more and more important. Herein, we report the phenomenon of multiple magnetic states and the different electronic transport behaviors driven by pressure in the bulk Mn_3GaC and Mn_3GaN . The magnetic structures were determined by neutron powder diffraction. The results show a possibility for stress to switch the spin in antiferromagnetic spintronic device.

Biography:

Prof. Dr. Cong Wang is a Professor at Beihang University, China. His work focuses on condensed matter physics, spintronics, antiperovskite materials, and solar-selective/radiative-cooling coatings. He holds a PhD from the Chinese Academy of Sciences and has held research positions in Germany, France, the UK, and the USA. He has published over 260 papers, holds several patents, and serves on multiple scientific committees and editorial boards.

Highly Efficient Room-Temperature Spin-Orbit Torque in an Epitaxial Half-Heusler Alloy NiMnSb Single Layer

Miao Jiang^{1,2,3,4,*}, Zeyu Han^{1,2,3}, Yongjun Huo^{1,2,3}, Yitao Yu^{1,2,3}, Huangyu Wu^{1,2,3}, Lihong Gao^{1,2,4}, Zhuang Ma^{1,2,4}, and Gang Zhang^{1,3}

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³*Yangtze Delta Region Academy in Jiaxing, Beijing Institute of Technology, Jiaxing, Zhejiang, P. R. China*

⁴*Materials Intelligent Innovation Laboratory (MIIL), Beijing Institute of Technology, Zhuhai, Guangdong, P. R. China*

Abstract:

A central challenge in spintronics lies in realizing highly efficient spin-orbit torque (SOT) magnetization switching at room temperature to advance the low-power magnetic memory and logic technologies. The conventional SOT systems rely on heavy metal/ferromagnet bilayer structures, in which the magnetization switching efficiency is constrained by the interfacial spin scattering, short spin diffusion lengths, and the inherent complexity of multilayered architectures. Meanwhile, the competition between the "bulk" spin Hall effect and the "interface" inverse spin galvanic effect has limited a deep

understanding of the physical mechanisms of SOT. Breaking the inherent crystal inversion symmetry of single-layer ferromagnets provides a direct pathway to generate current-induced spin polarization, effectively reducing the current density required for the magnetization switching. However, existing demonstrations of such systems have been confined to low-temperature operation or exhibited only moderate efficiencies. Achieving both room-temperature functionality and high efficiency remains a critical, yet unmet, challenge in spintronics.

To overcome the limitations mentioned above, we introduced a synergistic design of materials and structures in an epitaxial half-Heusler NiMnSb single layer. By employing a 45° rotational epitaxial alignment, we reduced the lattice mismatch to only 0.15% and achieved high crystallinity with atomically flat surfaces ($R_a \approx 0.45$ nm) utilizing high-vacuum magnetron sputtering. The SOT efficiency was confirmed to be 16.8 Oe/(10⁶ A/cm²) at room temperature in our NiMnSb single layer, which is higher than conventional Pt/Co bilayers and surpasses previously reported values for GaAs-based NiMnSb single layer. This breakthrough stems from NiMnSb's intrinsic non-centrosymmetric structure, half-metallic properties, and optimized epitaxial growth. Importantly, the single-layer architecture removes the need for complex multilayer stacks, enabling simplified fabrication, lower power consumption, and higher integration density—critical metrics for next-generation magnetic random-access memory. Our findings mark a pivotal advance toward the realization of practical, high-efficiency single-layer SOT memory technologies.

Biography:

Miao Jiang, Professor and doctoral advisor at Beijing Institute of Technology, received her Ph.D. from the University of Tokyo and was a JSPS Research Fellow. Her research spans spintronic materials and devices, as well as electromagnetic wave absorption and shielding, with a multidisciplinary background in materials science, physical electronics, and electronic engineering. She has made breakthrough advances in highly efficient single-layer magnetic memory devices, contributing to next-generation high-performance information storage technologies. Her work has been published in leading journals such as *Nature Electronics*, *Nature Communications*, and *Advanced Science*.

Nanoscale Distortions Produce Mesoscale Modulations in Li-Doped KTa/NbO₃ Perovskite Ferroelectrics

Raffaella Soave¹, Stefano Americo¹, Giovanni Macetti², and Leonardo Lo Presti²

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²*Università degli Studi di Milano, Department of Chemistry, Milano, Italy*

Abstract:

Tantalate-niobate solid solutions are perovskite-type crystalline ferroelectrics with groundbreaking optical properties, like giant broadband refraction ($n > 25$) across the entire visible and near infrared spectrum. At the Curie point, a coherent ordered 3D mesoscale structure emerges, which could be rationalized as a ferroelectric supercrystal composed by topological large-scale defects that self-organize. Although this mechanism has been supported for decades by indirect experimental evidence, to this day little is known about the local structure of the polar nanoregions (PNR), as well as their relative arrangement at the micrometer scale. Here, we report on an accurate multi-T single crystal X-ray study on a Li-doped tantalate-niobate system KLTN in the 300-90 K range of T. Three first-order structural phase transitions occur, which break the Pm-3m symmetry of the parent RT structure and induce uniaxial polarization within the unit cell, where Nb and Ta are displaced in opposite directions and Li is most probably off-centered. Density functional theory calculations performed on the parent structures help to rationalize the interplay between Li, Ta and Nb displacements observed in the solid solution. In

parallel, molecular dynamics simulations investigate the atomic structure at higher length scales (~10-100 nm), where the PNR emerge. This provides a basis to rationalize the structural origin of optical properties of KLTN, with potential applications in miniaturized circuitry and nonlinear optics.

Biography:

Raffaella Soave is a CNR Researcher at the Institute of Chemical Sciences and Technologies "Giulio Natta" in Milan, a position she has held since 2001. She earned her Specialization Degree in Materials Sciences and Technologies from the University of Milano-Bicocca in 2000 and completed her PhD in Chemical Sciences at the University of Milano in 1998. Her research focuses on determining molecular structures using single-crystal X-ray diffraction and on the computational modeling of organic and inorganic materials.

The Origin of the Spin-Peierls Transition in π -Stacked 1,2,3,5-Dithiadiazolyl Radicals

Yassine Beldjoudi^{1,2*}, Keitaro Eguchi³, Kunio Awaga³, Michio Matstichita³, Ana Arozo⁴, Javier Campo⁴, and Jeremy M. Rawson²

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Abstract:

Organic materials promise lightweight, sustainable platforms for next-generation electronics, spintronics, and energy devices, yet translating molecular designs into solid-state architectures with tailored properties remains a formidable challenge. Thiazyl-based radicals offer a diverse suite of functions—magnetism, and conductivity—and incorporating polyaromatic hydrocarbons into their core preserves emissive behavior while dramatically influencing packing. Planar derivatives self-assemble into one-dimensional π -stacked columns along the *a*-axis, whereas nonplanar analogs³ maintain monomeric arrangements in the solid state. Thermal studies revealed that the low-temperature transition from a distorted π -stack to a regular one is not merely entropy-driven but a concerted response to spin-state energetics within π -stacked dimers. Theoretical calculations have shown that as the *a*-axis expands, the stability of the quartet spin configuration increases, while the doublet state becomes energetically trapped in a shallow well when the stack approaches geometric uniformity—reflecting the interplay between lattice distortion and spin-gap energetics typical of Spin-Peierls (SP) systems. Notably, the high spin electronic-state stabilization along the π -stacking axis is the principal thermodynamic driver of the transformation. Magnetic susceptibility measurements confirm a large spin gap in the low-temperature SP phase ($\Delta E_{\text{spin}} \sim 2000 \text{ cm}^{-1}$), consistent with the existence of gapped alternating AFM 1D chain. Upon heating into the high-temperature phase, the spin gap closes and the materials evolve into uniform 1D AFM chains, with exchange constants $J \approx -200 \text{ cm}^{-1}$. Investigation of the electron transport revealed the existence a hysteresis of 25K and an OFF/ON/OFF conductivity behavior between 265-280K associated to the existence a charge-spin-phonon coupling near the phase transition boundaries (265-280K). These findings underscore how SP coupling is central to the observed structural

and electronic transitions in these π -stacked radicals, unifying the thermal, magnetic, and transport phenomena under a common electronic origin.

Biography:

Dr. Yassine Beldjoudi is an Associate Professor at the University of Nizwa, Oman, specializing in solid-state and supramolecular chemistry. He earned his PhD from the University of Windsor in 2016, focusing on thiazyl radicals, and previously studied in Paris. His research spans molecular tessellations, photocatalysis, and energy materials.

Atomic-Scale Characterization of Artificial Defects in Epitaxial Graphene by Scanning Tunneling Microscopy

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Abstract:

The interface between epitaxial graphene and SiC offers an atomically precise template for the epitaxy of 2D metal layers, which provide an appealing platform for nanoelectronics and quantum technology. To form such 2D crystals, metal atoms must enter the graphene/SiC interface through the defects in graphene. However, the atomic-scale understanding of defects that act like open nanoportals and govern the intercalation process remains very modest. Here, we generated artificial defects in graphene grown on SiC using different approaches and investigated their structures and electronic properties using low-temperature scanning tunneling microscopy (STM), corroborated by density functional theory (DFT). We found a broad spectrum of point defects that vary in size, shape, and symmetry, and are dominated by triangular species as a signature of monovacancy. Tunneling spectroscopy was used to identify defect-induced states in the vicinity of the Fermi level that significantly perturb the graphene electronic properties at the defect site. We simulated the local density of states of the defects and their corresponding STM images, which further helped us to identify the exact atomic configurations of the defects. The atomic-scale STM investigation, complemented by DFT simulations, provides ultimate microscopic details of defect configurations in graphene as well as further opens a way to identify the metal intercalation process with real-space resolution.

Biography:

Van Dong Pham earned a Ph.D. in condensed matter physics from Université Paris Cité in 2016. Following this, Dr. Pham worked as a Postdoctoral Researcher for one year at the Department of Physics, FAU Erlangen–Nuremberg, Germany, before joining the STM group at the Paul Drude Institute in November 2017. His research focuses on the electronic properties of condensed matter systems explored through scanning tunneling microscopy. In recent years, Van Dong Pham has initiated independent research at PDI on the STM investigation of 2D metals intercalated between graphene and SiC.

Gaussian Distribution of Barrier Heights in Pd/n-Type Si_{0.90}Ge_{0.10} Schottky Diode from Reverse Current-Voltage Characteristics

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²LERMA, Collège Ingénierie et Architecture, Université Internationale de Rabat, Parc Technopoles Rabat-Shore, 11100, Sala El Jadida, Morocco

Abstract:

Metal/semiconductor (M/Sc) rectifier contacts is one of the of the most advanced semiconductor device because of their technological interest in electronic and optoelectronic integrated circuits. Notably Schottky junctions of metal on *n*-type strained Si_{0.90}Ge_{0.10} epilayers are of technological interest for infrared detector applications. Extracting electrical parameters such as barrier height inhomogeneities (BHi) from the forward bias can be very challenging in M/Sc characterized by low barrier height and high series resistance. In this work we demonstrate for the first time that reverse bias can be used as an alternative method to substitute the forward electrical characteristics and investigate BHi of low barrier height in M/Sc contacts. In particular the BHi in Pd/n-type Si_{0.90}Ge_{0.10} Schottky barrier diodes were investigated using reverse current-voltage-temperature (*I_R-V_R-T*) measurements over a large temperature range (100–300 K). The temperature dependence of the reverse-bias barrier heights (Φ_{RBn}) was analyzed based on a thermionic emission (TE) current transport mechanism, associated with Gaussian distribution of the barrier height induced by BHi. The mean homogeneous barrier height (Φ_{RBn}) and its standard deviation (σ_{Rs}) were extracted at different reverse voltages, revealing a decrease in Φ_{RBn} and an increase in σ_{Rs} with increasing reverse bias. This result suggests that increasing reverse bias leads to a broader distribution of barrier heights induce by a large BHi upon applied reverse bias. The deduced average zero-field barrier height determined under flat band condition ($\Phi_{FB} \approx 0.84$ eV) from *I_R-V_R* measurements shows a strong agreement with the value obtained from forward bias. Furthermore, the reverse bias-derived Richardson constant (*A*^{*}) values, based on the BHi model, correlate well with the theoretical value of 112 A·cm⁻²·K⁻² for *n*-type Si_{0.90}Ge_{0.10} alloys. Finally, the results obtained in this work fully support the utilization of such reverse bias method.

Biography:

Mohammed Mamor received M.S and Ph.D. degrees in Physics of semiconductor materials from Joseph Fourier University in 1993 and University of Paris XI in 1996, respectively. Prof Mamor has produced more than 60 ISI scientific publications and contributed to 60 International Conferences mainly in Europe and USA. He is a Professor of applied physics at University of Cadi Ayyad, Morocco. Prior to that, he was a Faculty Member at Sultan Qaboos University. Prof Mamor was a Senior Research Fellow at Chalmers University of Technology, Sweden, where he conducted research on silicon device technology and radiation induced defects in semiconductor materials.

Judd-Ofelt Analysis of Pr³⁺: A Direct Emission Spectrum Approach for Advanced LED Phosphors and Scintillators

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²Inorganic Photoactive Materials, Institute of Inorganic Chemistry, Heinrich Heine University Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf, Germany

Abstract:

The Judd-Ofelt (JO) theory is foundational in lanthanide spectroscopy, providing a quantitative framework for understanding the intensities of electric-dipole transitions in rare-earth ions. Its three intensity parameters (Ω_2 , Ω_4 , Ω_6) are essential for predicting oscillator strengths, radiative rates, and optimizing materials for photonic applications such as solid-state lighting as LED phosphors, or scintillators. However, conventional JO analysis relies on absorption spectra, which is problematic for non-transparent or polycrystalline materials, and especially challenging for Pr^{3+} ions due to configuration mixing and overlapping energy levels.

In this work, we present an emission-based algorithm for extracting JO parameters of Pr^{3+} , demonstrated on $\text{Sr}_2\text{LaF}_7:\text{Pr}^{3+}$ nanopowders. This method circumvents the limitations of absorption-based analysis by utilizing emission spectra, specifically transitions from both the $^3\text{P}_0$ and $^1\text{D}_2$ excited states. By employing temperature-dependent and time-gated photoluminescence spectroscopy, we isolate emissions from these levels, enabling accurate determination of JO parameters even in the presence of non-radiative relaxation pathways and spectral overlap.

Our approach demonstrates that, for low-phonon energy hosts like fluorides, the $^3\text{P}_0$ decay is nearly purely radiative, allowing direct extraction of Ω_2 , Ω_4 , and Ω_6 from emission intensities. For mid-phonon energy hosts (e.g. oxides), we extend the analysis to include $^1\text{D}_2$ emissions, using decay time calibration and spectral deconvolution.

This emission-based JO analysis is particularly significant for the rational design of Pr^{3+} -activated LED phosphors or scintillators, where maximizing radiative efficiency and tuning emission color is critical. Our results establish a robust protocol for JO parameterization in challenging material systems, advancing the development of next-generation photonic materials.

Biography:

Dr. Aleksandar Ćirić is a research associate at the Vinča Institute of Nuclear Sciences, University of Belgrade, with expertise in optical materials, spectroscopy, and nanotechnology. He has authored more than 70 scientific publications and is recognized on the Stanford list of the world's top 2% most influential scientists. His research centers on luminescent materials and optical sensing, with a particular emphasis on the Judd-Ofelt theory of lanthanides. Dr. Ćirić is dedicated to advancing the theory's applications and methods of parametrization, as well as developing scientific software to support these calculations.

Uniformly Assembled 2D-Engineered Electroactive CuO Nanoleaflet Sensor for Glucose Monitoring

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Abstract:

Hydrothermally synthesized two-dimensional copper (II) oxide (CuO) nanoleaflets were studied as a

label-free, non-enzymatic glucose sensor in neutral aqueous media. A one-pot hydrothermal route with copper nitrate and a mild base yielded uniform ultrathin leaflets, as confirmed by scanning electron microscopy (SEM) (average edge length 26.65 ± 0.31 nm) and energy-dispersive X-ray spectroscopy (EDX) (composition ~ 33.6 % Cu, 34.9 % O, 31.5 % C). Electrochemical measurements using a glassy carbon electrode and Ag/AgCl reference in cyclic voltammetry revealed distinct Cu (II)/Cu (III) hydroxide and oxy-radical redox peaks at neutral pH, with peak currents scaling linearly with the square root of scan rate, indicating diffusion-controlled reversible kinetics. Chronoamperometric analysis at +0.225 V vs. Ag/AgCl achieved a glucose limit of detection (LOD) of 2.43×10^{-3} mol·L⁻¹ (43.78 mg·dL⁻¹), spanning the hypoglycemic range. Rapid response times (< 5 s) and high reproducibility (relative standard deviation < 4 % over five trials) underscored the sensor's analytical reliability. Testing with gentian violet (0.34–0.74 mg·L⁻¹) demonstrated significant suppression of the oxidation signal, highlighting the need for selective surface modifications or sample pretreatment in complex matrices. The scalable, cost-effective fabrication, high surface area, and reversible redox behaviour of these CuO nanoleaflets establish their potential for integration into portable diabetes management platforms. Future efforts will focus on enhancing selectivity via functional coatings, extending the dynamic range, and validating performance in whole blood or interstitial fluid for point-of-care diagnostics.

Biography:

Dr Sisonke Olothando Sigonya is a postdoctoral research fellow at the University of South Africa, specializing in 2D nanomaterials and biosensor development for diabetes biomarkers. With a PhD in Chemistry focused on electrospun composite membranes and an MSc optimizing pollutant extraction techniques, she combines advanced analytical expertise including HPLC, GC-MS, UV-Vis, and FTIR with nanomaterials synthesis, characterization and quality control processes. Her current work centers on engineering graphene and metal oxide nanosheets for non-enzymatic glucose sensing in neutral media. Dr Sigonya excels in interdisciplinary collaboration, mentoring graduate students, facilitating workshops, and bridging academic and industry partnerships to pioneer sensitive, low-cost diagnostic platforms.

Structural, Magnetic and Magnetocaloric Performance of Double Layered Manganites and Potential Utilization of Van der Waals Compounds

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²*Department of Materials Convergence and System Engineering, Changwon National University, Changwon, Gyeongnam, 51140, Republic of Korea*

Abstract:

We investigated the magnetocaloric (MC) performance of unconventional materials like Ruddlesden-Popper (R-P) oxides and the magnetic properties of Van der Waals heterostructures. In La_{1.4-x}Sm_x/Pr_xCa_{1.6}Mn₂O₇ (x = 0.0-0.4), controlled substitution of Sm and Pr for La was performed to enhance magnetic and MC properties. Samples synthesized via solidstate reaction were confirmed to have a bilayer tetragonal structure (I4/mmm) using Rietveld refined XRD. Incorporation of Sm/Pr induced chemical pressure, affecting bilayer symmetry. While Pr³⁺ has an ionic radius similar to La³⁺, the smaller Sm³⁺ ion disrupts the tetragonal lattice more effectively. Sm substitution significantly improved magnetic entropy change (ΔS_m) and temperature-averaged entropy change (TEC). The Sm-doped x = 0.3 sample

exhibited the highest ΔS_m ($6.71 \text{ J kg}^{-1} \text{ K}^{-1}$) and TEC ($9.017 \text{ J kg}^{-1} \text{ K}^{-1}$) at 2.5 T, while Pr-doped samples achieved a ΔS_m of $6.16 \text{ J kg}^{-1} \text{ K}^{-1}$ and TEC of $8.329 \text{ J kg}^{-1} \text{ K}^{-1}$ at $x \geq 0.3$. Additionally, structural and magnetic properties of graphene oxide (GO) heterostructures functionalized with transition metal oxides, such as Mn_3O_4 , were studied. Transition metal compounds with flexible oxidation states enhance functionalization with GO, confining spin wave propagation over the 2D surface. This interaction induces significant magnetic moments in GO heterostructures, contributing to a notable magnetocaloric effect.

Biography:

Dr. Akshay Kumar completed his Ph.D. in 2022 in the field of Advanced Materials from the esteemed Department of Materials Science and Engineering at Changwon National University (CWNU), South Korea. During his doctoral studies, Dr. Akshay Kumar delved into the fascinating world of magnetocaloric (MC) phenomena in quasi two-dimensional materials. With expertise in MC materials, Dr. Kumar secured two Korean patents, each pertaining to innovative magnetocaloric measurement techniques and devices.

Highly Efficient Polymeric Electrochromic Devices- Modifying the Chemical Structure of the Chromophores and the Polymer Backbone

Laura Maggini*, and Davide Bonifazi

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Abstract:

Electrochromic devices (ECDs) are gaining increasing attention in modern digital display technologies due to their excellent outdoor readability, mechanical flexibility, straightforward fabrication, and low-voltage operation. ECDs function based on electrochromism, a reversible change in color or transparency in response to an applied electric field or current, typically involving redox-driven modulation of optical properties such as transmittance and reflectivity. With growing interest in integrating electrochromism into flexible and wearable electronics, key challenges include achieving high energy efficiency, rapid switching speeds, and long-term durability without compromising device flexibility.

Among various electrochromic materials, both inorganic and organic, polymer-based electrochromic materials have emerged as particularly promising due to their low cost, lightweight nature, and inherent flexibility. In this study, we explore a modular synthetic approach to tailor chromophore structures and optimize polymer backbones, aiming to develop highly efficient, recyclable, fast-switching, and flexible electrochromic materials suitable for commercial applications.

Structural tuning of chromophore units allows for color modulation, enabling a broader palette of hues without significantly impacting the overall performance of the material. Our findings demonstrate that rational design of both chromophore and polymer structures contributes significantly to the development of next-generation polymeric ECDs with potential for scalable commercialization.

Biography:

Dr. Laura Maggini is a researcher at the University of Vienna, specializing in the design and scalable production of functional organic materials. Her work bridges organic synthesis, materials science, and device integration, with a strong emphasis on flexible and sustainable electronics. She is also actively

involved in the development of a spin-off initiative aiming to commercialize innovative electrochromic technologies for smart displays and wearable devices. Her interdisciplinary approach drives the translation of fundamental research into real-world applications.

Carbon Nanotube Device Engineering

Taher Ghomian^{1,2}

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²*Frontier Institute for Research in Sensor Technology, University of Maine, Orono, ME 04469, United States*

Abstract:

Carbon nanotubes (CNTs) continue to attract significant attention in the materials science community due to their remarkable electrical, mechanical, and chemical properties. In particular, devices based on single or a few CNTs offer exciting opportunities for studying nanoscale transport phenomena and for developing high-performance devices. However, translating these unique properties into reproducible device performance requires careful control over fabrication processes and material interfaces.

This presentation provides an overview of the engineering and integration of single/few-CNT devices, highlighting techniques for precise placement, contact formation, and substrate interaction control. In particular, fabrication approaches and strategies to minimize variability in device performance will be discussed. Emphasis will be placed on practical challenges in working with low-density CNTs and how material processing affects device behavior.

Beyond fabrication, the application of these devices in general sensing contexts will be discussed. Examples will include chemical and environmental sensing, where CNT-based devices exhibit high sensitivity due to their large surface-to-core ratio. The potential for operation in liquid environments, as well as compatibility with impedance-based or label-free detection schemes, will also be discussed.

Overall, this work aims to connect the fundamental materials aspects of carbon nanotubes with device-level engineering and real-world applications. By doing so, it offers insights into how advances in materials science can drive the development of next-generation nanoelectronic and sensing technologies.

Biography:

Dr. Taher Ghomian is an Assistant Professor in the Department of Electrical and Computer Engineering and a member of the Frontier Institute for Research in Sensor Technologies at the University of Maine. His research focuses on studying and customizing the properties of nanoscale materials and using this knowledge to fabricate sensors and energy harvesters. He worked as a Postdoctoral Scholar at the University of California, Davis, developing devices for nanomaterial manipulation and studying the energy conversion properties of nanomaterials. He pioneered the development of a solution-processed photovoltaic device that harvests human body thermal radiation. He is a Senior Member of IEEE.

Exploring Thermoluminescence Properties of Gadolinium Aluminum Borate Phosphors Doped with Europium: Effects of Europium Incorporation Under Beta Radiation

Osama Madkhali

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Abstract:

This research investigates the thermoluminescence (TL) behavior and kinetic characteristics of europium (Eu^{3+})-doped gadolinium aluminum borate ($\text{GdAl}_3(\text{BO}_3)_4$, or GAB) phosphors synthesized using the sol-gel technique. The influence of Eu^{3+} incorporation on the crystalline structure of undoped GAB was studied through X-ray diffraction (XRD), confirming that the doped samples preserved the rhombohedral phase aligned with the PDF#72-1985 reference pattern. TL glow curve analysis of Eu^{3+} -doped GAB revealed three distinct emission peaks occurring near 86 °C, 185 °C, and 300 °C. The phosphor containing 1 wt% Eu^{3+} demonstrated the highest TL intensity. The optimal thermal treatment for erasing the TL signal corresponding to the 86 °C peak was established as heating to 135 °C for 16 seconds. Over a storage period of three months, the TL signal showed a 14.71% decline. The minimum detectable dose (MDD) was found to be 1.290 ± 0.02 mGy, highlighting its effectiveness for detecting low radiation levels. A linear dose-response relationship was maintained over a broad exposure range (2–300 Gy), with consistent sensitivity. Analysis via the Ea-Tstop method identified six glow peaks, with associated activation energies spanning from 0.99 eV to 1.18 eV, reinforcing the material's potential for use in radiation dosimetry.

Biography:

Dr. Osama Madkhali is an accomplished physicist and material scientist with over nine years of experience. As an assistant professor at Jazan University, he leads cutting-edge research in nanomaterials, renewable energy, energy storage, thin films, and optoelectronic devices. He earned his bachelor's from Jazan University, master's from Western Illinois University, and Ph.D. in Material Science from University of Lorraine. Dr. Madkhali has published extensively, presented internationally, and actively mentors students. His numerous awards and contributions to research and education continue to inspire future scientists and advance ground-breaking technologies, including an upcoming pioneering book in the field. His work remains transformative.

Young Researchers Presentations

On the Strong Composition Dependence of the Martensitic Transformation Temperature and Heat in Shape Memory Alloys

Asmaa A. Azim^{1,2*}, and Dezső L. Beke¹

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²*Physics Department, Faculty of Science Ain Shams University, Abbassia, Cairo 11566, Egypt*

Abstract:

Shape memory alloys (SMAs) are materials that remember their original shape, thus, they are of great interest due to their wide applications in e.g. actuators and medicine. This unique behavior is due to a diffusionless transformation in their atomic structure, known as the martensitic transformation. This transformation can be initiated thermally, mechanically by stress or compression, or by applying

magnetic field. When this transformation is thermally induced, the temperature at which this transformation happens depends strongly on the alloy's composition. In this work, we showed how the transformation temperature and the heat involved in this process are influenced by composition. Using fundamental principles of “similarity of interatomic potentials”, the dimensionless values of the heat of transformation, and entropy, as well as the elastic constants are universal functions not only of the homologous temperature, $\frac{T}{T_m}$, but depend on a new dimensionless variable, $\frac{T_o}{T_m}$, describing the phonon softening (T_m and T_o are the melting point and the equilibrium martensitic transformation temperature). $\frac{T_o}{T_m}$ has the same value in SMAs with the same type of crystal symmetry change during martensitic transformation. This approach helps to understand how different SMAs with the same crystal symmetry change follow similar trends^[1]. This work gives guidance in designing and optimizing SMAs for applications in medicine, robotics, and aerospace.

References:

[1] Beke, D. L., & Azim, A. A. (2024). On the Strong Composition Dependence of the Martensitic Transformation Temperature and Heat in Shape Memory Alloys. *Materials*, 17(16), 4116. <https://doi.org/10.3390/ma17164116>

Biography:

Asmaa A. Azim holds a BSc from Ain Shams University, Egypt, where she also served as a teaching assistant in the Department of Physics, Faculty of Science. Since 2023, she has been pursuing a PhD in solid-state physics at the University of Debrecen, Hungary, under the Hungarian scholarship program. Her research, supervised by Prof. Dezső Beke, focuses on studying the noisy character of structural changes.

Symposium III: Nanotechnology and Nanomaterials

Featured Presentations

Atomistic Simulation for Nanoparticle and Nanodevice Design

Panagiotis Grammatikopoulos

Instituto Regional de Investigación Científica Aplicada (IRICA) and Departamento de Física, Universidad de Castilla-La Mancha, 13071, Ciudad Real, Spain

Abstract:

Cluster beam deposition (CBD) is a term that collectively describes various physical methods of nanoparticle synthesis by nucleation and growth from a supersaturated atomic vapour. It provides a solvent- and effluent-free method to design monodisperse multifunctional nanoparticles with tailored characteristics that can be subsequently deposited on a desired substrate or device in the soft-landing regime under ultra-high vacuum. In this talk, I will explain the main mechanisms that control the basic properties of individual nanoparticles such as size, shape, or chemical ordering, based on various setups of CBD sources. Moving to a coarser scale, I will bring up examples where larger structures can be designed using nanoparticles as their functional building blocks, such as novel sensors and energy storage devices. To date, CBD faces two main limitations that need to be overcome for real-world applications: (i) limited yield, and (ii) precise structural control. The main thesis of this talk is that both challenges can be tackled by in-depth theoretical understanding of both the thermodynamics and kinetics of nucleation & growth. To this end, atomistic computer modelling can be an invaluable tool, complementing experimental fabrication and guiding future source design.

Biography:

Panagiotis Grammatikopoulos is a computational nanotechnologist. His research focuses on fundamental processes regarding nanoparticles but extends to device fabrication and applications. Panagiotis did his PhD at the University of Liverpool, UK. He has worked as a Research Associate for NCSR Demokritos, Greece, and the University of Greenwich, UK, and as Group Leader at OIST, Japan. Since 2020 he has been a Visiting Assistant Professor at ETH Zürich, Switzerland, Specially Appointed Assistant Professor at Osaka University, Japan, and Associate Professor at GTIIT, China. Panagiotis is currently Profesor Distinguido “Beatriz Galindo” at UCLM, Spain.

Advanced Characterization of Oxide Nanomaterials Using Infrared Spectroscopy

Iñigo González de Arrieta^{1*}, Mireia Sainz-Menchón¹, Telmo Echániz², and Gabriel A. López¹

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²*Applied Mathematics, University of the Basque Country (UPV/EHU), E-48013 Bilbao, Spain*

Abstract:

Spectroscopic techniques are essential tools for the characterization of novel nanomaterials and nanocomposites. For example, Raman spectroscopy is widely used to study vibrational modes and how they change with decreasing particle size. In the case of infrared spectroscopy, however, its application to nanomaterials has been traditionally more qualitative, mainly concerned with the rough identification of phases and adsorbed molecules. This is because quantitative studies require extracting the dielectric

function, for which it is necessary to consider the influences of porosity, network connectivity, and particle shape and arrangement on the electromagnetic response of the matrix + nanomaterial composite. To this end, we show that a method based on reflectance spectroscopy and effective medium theories can provide quantitative results regarding the structural properties of dielectric nanomaterials. In particular, extending the measurements to the far infrared allows quantifying low-frequency modes, which are absent in most reported spectra but rich in features that can be used to identify phases with similar crystal structures. The fundamentals of the technique are demonstrated in a reference material, CeO_2 , and its generality is proven through several case studies: phase discrimination in $(\gamma,\delta)\text{-Al}_2\text{O}_3$ and mixed $\text{Fe}_3\text{O}_4/\gamma\text{-Fe}_2\text{O}_3$ nanoparticles, as well as quantification of short-range order in the case of vitreous SiO_2 .

Biography:

Iñigo González de Arrieta obtained a PhD in Physics from the University of the Basque Country (UPV/EHU) in 2020. Following the PhD, Dr. González de Arrieta worked as a post-doctoral fellow at UPV/EHU and at CNRS Orléans in France, before securing an Assistant Professor position at UPV/EHU in September 2023. Research topics include emissivity measurements, infrared spectroscopy, materials for energy, and physics education. The current focus is on expanding the applications of infrared spectroscopy for the characterization of heterogeneous materials across a wide range of applied and fundamental fields.

Ternary $\text{W}_x\text{Ti}_{1-x}\text{O}_2$ and Heterostructured $\text{TiO}_2\text{-WO}_{3-x}$ Nanoarchitectures: Scalable Microwave-Assisted Synthesis, Hot-Carriers Dynamics and Photocatalytic Effectiveness in the Solar Range

Riccardo Scarfiello^{*,1,2}, Michele Guizzardi³, Armando Genco³, Concetta Nobile¹, Marianna Bellardita⁴, Giulio Cerullo³, Leonardo Palmisano⁴, and Luigi Carbone^{1,2}

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Abstract:

Microwave (MW) powered hydro-alcoholothermal synthetic approach to generate ternary $\text{W}_x\text{Ti}_{1-x}\text{O}_2$ and nano-heterostructured $\text{TiO}_2\text{-WO}_{3-x}$ nanocrystals (NCs) will be exhaustively reported and carefully discussed. Among conventional solvothermal and hydrothermal synthetic methodologies, microwave (MW)-assisted synthesis benefit from unquestioned advantages such as the drastic reduction of processing time and the subsistence of specific MW effects: (i) superheating of solvents (ii) selective heating of specific reactants (iii) exclusion of wall effects and (iv) kinetic events due to the very fast heating of selected reactants. Those aspects make the MW-synthetic approach extremely fast and reproducible, confining to few minutes the reaction growth time and empowers the size and individual-particle control at the nanoscale, opening the way toward grams-scale of earth-abundant and non-toxic nanomaterials via modular production. The effectiveness of MWs in favoring the growth of a second phase onto pre-existing seeds is proved, and therefore their uniqueness in boosting uncommon reaction paths. $\text{TiO}_2\text{-WO}_{3-x}$ heterostructures demonstrated to behave as plasmonic non-metal/semiconductor heterojunction photocatalysts, confirmed by time-resolved spectroscopy experiments on the WO_{3-x} domain that reveals the formation and the ultrafast cooling processes of hot electrons, in principle available for high-energy reactions. The colloidal stability of the reported water-soluble ligand-free

samples, guaranteed without the need of any post-synthetic treatment and/or the use of specific surfactants, allows nanocrystalline surfaces to be unhindered for expressing several functional properties, leading the way to a broad window of possible functional applications. One example can be homogeneous and heterogeneous photocatalysis. Both ternary $W_xTi_{1-x}O_2$ and TiO_2-WO_{3-x} nano-heterostructure exhibit important photo-oxidant activity toward alcohol molecules in the liquid environment with enhanced selectivity toward aldehyde and carboxylic acid. Photocatalytic studies suggest the prominent role of hot carriers in the high photooxidation activity and selectivity of TiO_2-WO_{3-x} nano-heterostructure under simulated solar light and UV radiation.

Biography:

Dr. Riccardo Scarfiello joined the CNR Nanotec Lecce as permanent researcher from December 2021. He is specialized in developing innovative surfactant-assisted non-hydrolytic synthetic strategies and the corresponding morphological, structural, and spectroscopic characterization of inorganic nanocrystals (especially WO_{3-x} , $Cu_{2-x}S$, TiO_2 , WS_2 , WSe_2 , and TiS_2). More recently, he integrated conventional colloidal synthesis with microwave powered inorganic synthetic methodologies for nanocrystal generation, approaching to a greener and scalable nano-chemistry, preserving precise control over composition, shape, and size. The absence of alkyl chain organic shells on the nanocrystal surface allows simpler deposition techniques and broader application areas overtaking typical laboratory-scale prototypes.

Engineered Hybrid Nanoscintillators for Simultaneous High LY and Ultrafast Bimolecular Processes Towards < 20 ps Coincidence Time Resolution in ToF-PET

Irene Villa¹, Jacopo Perego¹, Lorena Dharmo¹, Alessia Landella¹, Charl Bezuidenhou¹, Silvia Bracco¹, Valeria Secchi^{1, 2}, Ilaria Mattei³, Nicolò Pianta¹, Vojtech Zabloudil⁴, Carsten Lowis⁴, Martin Nikl⁵, Francesco Meinardi¹, Etienne Auffray⁴, Angiolina Comotti¹, and Angelo Monguzzi^{1, 2}

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Abstract:

Medical imaging ToF-PET technique based on bulk crystalline scintillators displays inadequate coincidence time resolution (CTR) hindering high spatial resolution quality in diagnostic images. Overcoming this issue requires a new concept of fast and highly emissive metascintillators with CTR < 100 ps. They consist of a dense but slow emitting material guaranteeing efficient interaction with ionizing radiations, coupled to a light but fast scintillator.^[1] Its fast emission is activated by an ultrafast energy sharing mechanism from the dense material, thus accelerating the global scintillation kinetics and therefore improving the CTR. This work presents two ToF-PET scanners pixel prototypes based on metascintillators with ad hoc qualities in terms of elements' composition and electronic properties to maximize the stopping power and energy deposition of gamma rays, involving its conversion to emissive molecular excitons.^[2] In the first prototype, the heterostructure is made by layers of standard BGO and HfO_2 based nanocomposites.^[3] In the second one, homo-/hetero-ligand MOF films^[4] are used as fast scintillating part grown on dense scintillating dense crystals to optimize the energy sharing and the optical coupling between the layers. The metascintillator architecture allows to reach both high

luminescence and fast timing performances by tuning the ultrafast energy transfer processes within the systems' moieties that enable sub-nanosecond ultrafast scintillation pulses with LY that resembles the ones of best commercial fast emitting plastic scintillators towards the achievement of ToF-PET's CTR goal.

References:

- [1] Adv. Mater. Technol. 2302075, 2024
- [2] Nano Lett. 24, 8248, 2024
- [3] Adv. Funct. Mater, 2421434, 2024
- [4] Nat Photonics, 15 (5), 2021; Adv Funct Mater, 34 (44), 2024

Biography:

Irene Villa's research focuses on luminescent nanomaterials for the development of innovative therapies and highly sensitive ionizing radiation detectors in the oncological field. She is a recognized expert in steady-state and time-resolved ultrafast radio- and photoluminescence techniques for investigating the electronic and excited-state properties of inorganic and hybrid nanoparticles, as well as scintillating composites. Her work aims to tailor material performance for applications ranging from physics to biotechnology, while also advancing new models to understand scintillation mechanisms at the nanoscale. This research is supported by projects such as IF-MSCA-HANSOME and the EU-funded Next Generation EU MINERVA initiative.

Study of Water and Ethanol Sorption in ZIFs for Heat Storage

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¹National Institute of Chemistry, 1000 Ljubljana, Slovenia

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Abstract:

Growing global population and energy demand are increasing the need for heating and cooling, which now accounts for up to 50% of final energy use. This has driven interest in sustainable thermal energy storage and conversion methods. Sorption-based approaches offer benefits such as low heat loss and high energy density. Among potential materials, zeolites and metal-organic frameworks (MOFs) — particularly Zeolitic Imidazolate Frameworks (ZIFs) — show promise. ZIFs, composed of transition metal ions (e.g. Zn, Co) and imidazolate linkers, have zeolite-like structures and exhibit high thermal and chemical stability. Their porous nature makes them suitable for adsorption processes. While most studies focus on water as the working fluid, ethanol offers advantages for low-temperature applications and improved cycling stability in some ZIFs. However, large-scale ZIF deployment is constrained by expensive, unsustainable synthesis methods. Conventional solvothermal synthesis is energy-intensive, time-consuming, and often relies on toxic solvents like DMF, which has been restricted in the EU since 2023. In response, greener methods using alternative solvents, room-temperature processes, and ball milling are being developed. This study investigates a selection of ZIFs for thermal applications using water and ethanol. Seven structures were examined: five large-pore (ZIF-8, ZIF-71, ZIF-76, ZIF-90, ZIF-93) and two small-pore (ZIF-62, ZIF-74) types, chosen based on pore entrance and capacity. All were synthesised and characterised, with green synthesis optimised for the five main candidates. Sorption tests revealed ethanol adsorbs at lower pressures and is less affected by hydrophobic groups, though

water uptake was lower. Ethanol also induced less structural degradation over repeated cycles. Overall, ZIF-93 exhibited the best balance of performance and stability with both fluids, identifying it as a strong candidate for sorption-based heat storage and transformation systems.

Biography:

Ciara Byrne's research focuses on materials science and inorganic chemistry, with particular emphasis on the synthesis and modification of nanomaterials such as TiO₂ and ZIFs for environmental and energy applications. During her PhD at the Institute of Technology Sligo in Ireland, she developed doped TiO₂ nanomaterials to enhance the photocatalytic degradation of 1,4-dioxane and examined the influence of dopants on the anatase-to-rutile phase transition. She is currently based at the National Institute of Chemistry in Slovenia, where she investigates nanoporous ZIF materials for thermochemical energy storage using water, ethanol, and methanol as working fluids. Dr. Byrne is also habilitated at the University of Nova Gorica as an assistant for the courses Metal–Organic Frameworks and Materials Chemistry.

Development and Characterization of Thermoplastic Starch Composites with Carrageenan Additive and Reed Biomass Derived Reinforcement

Remo Merijs-Meri^{1*}, Janis Zicans¹, Tatjana Ivanova¹, Alina Lebedeva¹, Peteris Patriks Jefimovs¹, Ivans Bockovs¹, Juris Bitenieks¹, Rita Berzina¹, Karina Balina², and Uldis Zaimis²

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Abstract:

Hydrosphere is huge yet incompletely utilized source of renewable materials. Aquatic biomass, particularly, algae, offers raw materials for production of great diversity of different products for biomedicine, pharmacy, cosmetics, food & beverage, packaging, construction and even electronics applications. In the current research development of thermoplastic composites is carried out from starch, seaweeds' carrageenan and reeds. Thermoplastic processability of the developed compositions is tailored by using appropriate amounts of suitable plasticizer (glycerol, isosorbide). Performance of the developed biocomposites is evaluated by determining its rheological, thermal, mechanical and surface hydrophobic/hydrophilic properties. Sustainability of the developed biocomposites is evaluated by LCA. Potential application areas of the developed composites include but are not limited to green binders of building materials and melt processable compositions for biodegradable single-use products. This research is funded by the project Valorisation of local aquatic biomass to develop environmentally friendly composite material (AQUABOND) (Nr. RTU-PA-2024/1-0048).

Biography:

Prof., Dr.sc.ing. Remo Merijs-Meri is leading researcher at Riga Technical University, having acquired long years' expertise in polymer materials and technology.

Mucoadhesive and Nanoparticle-Based Drug Delivery System for Oral Mucosa: Production and *In Vitro* Evaluation

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[§]*These authors equally contributed to the manuscript.*

Abstract:

Background:

Oral lichen planus (OLP) is a chronic autoimmune disease affecting the oral mucosa and classified among oral potentially malignant disorders (OPMDs). Characterized by keratinocyte apoptosis and persistent inflammation, OLP is typically managed with topical corticosteroids delivered through mouthwashes, gels, or ointments. However, these conventional formulations present limitations, including reduced retention time in the oral cavity, frequent reapplication, and the risk of local and systemic side effects.

Objective:

This study aimed to develop and evaluate a novel drug delivery system for dexamethasone targeted to the oral mucosa. The proposed platform combines poly(lactic acid) (PLA) fibers coated with chitosan (CS) for mucoadhesion, and poly(lactic-co-glycolic acid) (PLGA) nanoparticles for efficient intracellular drug delivery.

Methods:

CS-coated PLA fibers were fabricated and assessed for mucoadhesive capacity and cytocompatibility. PLGA nanoparticles encapsulating dexamethasone were prepared and characterized for particle size, morphology, drug loading efficiency, cellular uptake, release profile, and biocompatibility. The combined system was tested under simulated salivary conditions to evaluate its performance in a dynamic oral environment.

Results:

Both the CS-coated PLA fibers and PLGA nanoparticles demonstrated excellent cytocompatibility. The chitosan-coated fibers exhibited strong mucoadhesive properties, ensuring prolonged retention on the mucosal surface. PLGA nanoparticles were efficiently internalized by oral epithelial cells and successfully delivered dexamethasone into the cytoplasm with a controlled release profile. The integrated system provided dual functionality, maintaining adhesion and intracellular delivery even under simulated salivary flow.

Conclusions:

The proposed delivery platform represents a promising strategy for enhancing the topical treatment of OLP, offering improved mucoadhesion and effective targeted drug release. Further optimization and in vivo validation are necessary to confirm its therapeutic potential and patient compliance benefits.

Biography:

Giuseppina Nocca is an Associate Professor of Biochemistry at the Università Cattolica del Sacro Cuore in Rome, Department of Basic, Clinical, Intensive Care and Perioperative Biotechnological Sciences. She conducts research within the Biochemistry section of the same university. Her scientific work focuses on areas such as biochemistry and toxicology, with particular interest in the development of innovative drug delivery systems and the use of biomaterials in the dental field. She is the author of numerous peer-reviewed publications and actively participates in interdisciplinary research projects, collaborating with

academic and healthcare institutions, including the Fondazione Policlinico Universitario A. Gemelli IRCCS.

Anti-Wear Laser Dimples on Ti/HAp Bio Composites Loaded with Gentamycin

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²*Cracow University of Technology, CUT Doctoral School, Cracow, Poland*

Abstract:

This research aims to demonstrate an innovative material system developed using the powder metallurgy method of biomaterial preparation for regenerative medicine. Utilizing the LT technique to achieve the desired pore structure on the implantable biomaterial ensures a rich supply of biologically active components like gentamycin. Furthermore, the dimples' laser texturing (LT) improves wear resistance. The resulting gradient structure consists of two compositions, Ti6Al4V alloy + 5% CMC (carboxymethylcellulose) and Ti6Al4V alloy + 10% CMC + 5% HAp (hydroxyapatite), to mimic the structure of bone tissue (cortical and trabecular layer). The developed composite material achieved the porosity range from 15-20% with the pores of 10-100 μm in size, enabling bone cells to penetrate the implant and regenerate bone. Laser-textures using the drilling technique, creating holes with a mean diameter of $45.5 \pm 0.2 \mu\text{m}$ and a depth of $66.5 \pm 0.2 \mu\text{m}$. With a raster of 100 μm . The LT porous part was superbly hydrophilic, soaking gentamycin within one 1second after implementation. The study of gentamycin release was conducted to assess therapeutic effectiveness. Free amino groups reacted with ninhydrin, forming a colored compound. The intensity of the coloration was proportional to the amount of released gentamicin, which was measured spectrophotometrically. Linear SEM/EDS measurements confirmed the presence of all elements characteristic for Ti6Al4V alloy and HAp in the composite. The roughness profile unveils a smooth sintered Ti6Al4V part where roughness oscillates around 0.2 μm and a porous Ti/HAp layer 100 μm thick after laser texturing with roughness over 20 μm .

Acknowledgements: The authors gratefully acknowledge financial support of the project “New Generation of Bioactive Laser Textured Ti/Hap Implants” under acronym “BiLaTex” carried out within M-ERA.NET 3 Call 2022 programme in the National Centre for Research and Development under registration no.: ERA.NET3/2022/48/BiLaTex/2023.

Biography:

Agnieszka Maria Tomala received a PhD in Physics from the Vienna University of Technology in 2010. She participated in EC Marie Skłodowska-Curie Actions PhD exchange programs at SKF and Imperial College London and published over 30 peer-reviewed papers in bio-tribology while working at the Austrian Excellence Centre for Tribology. Experience gained during the POLONEZ fellowship led to awarded funding from the M-ERA.NET Call 2018 project at the Łukasiewicz Research Network – Institute for Sustainable Technologies. Agnieszka Maria Tomala is currently leading the M-ERA.NET Call 2022 and OPUS LAP projects in bioengineering and biomaterials at the Cracow University of Technology, Faculty of Materials Science and Physics.

Tailored Chemistry of Magnetic Nanomaterials for Neural Control

Danijela Gregurec

Abstract:

Advances in materials chemistry are enabling a new generation of magnetic nanomaterials designed to interact with the nervous system through wireless, multimodal stimulation. My research centers on the new synthetic approaches and functionalization of anisotropic and core-shell magnetic nanoparticles that transduce magnetic fields into precise mechanical, thermal, or electrical signals. We introduced vortex-state magnetite nanodiscs for magnetomechanical neuromodulation, capable of producing piconewton-scale torques to activate mechanosensitive neurons under low-frequency fields. In the thermal domain, these anisotropic magnetite nanoparticles achieve effective magnetothermal stimulation of TRPV1-expressing neurons at concentrations orders of magnitude lower than conventional SPIONs.

Embedding anisotropic ferrites into flexible, piezoelectric polymers enable the fabrication of soft, subdural implants for localized neuromodulation with minimal invasiveness for transgene-free electrical stimulation of neural tissues. These magnetoelectric effects were harnessed by coating anisotropic magnetite with $\text{CoFe}_2\text{O}_4/\text{BaTiO}_3$, increasing Magnetoelectric coefficient beyond what is possible with conventional multiferroics. Our efforts towards colloidal stability and reproducibility led to novel synthetic strategies exhibiting enhanced polarization behavior and efficient magnetoelectric transduction, offering new capabilities for nanoscale bioelectronic interfaces.

This talk will highlight how tailored nanoscale structure, interface chemistry, and magnetic properties converge to unlock new functional pathways for wireless interaction with neural systems.

Biography:

Dr. Danijela Gregurec is an Assistant Professor at FAU Erlangen, where she leads the Biointerfaces Group developing functional nanomaterials for wireless control of biological systems, with a focus on neurobiology. She earned her PhD at CIC biomaGUNE (Spain) and completed postdoctoral research at MIT (USA), advancing anisotropic magnetic nanostructures for remote neural stimulation. Her work bridges materials chemistry and neurotechnology, emphasizing magnetothermal, magnetomechanical, and magnetoelectric modalities. She also develops novel synthetic routes for anisotropic and core-shell nanoparticles. Dr. Gregurec has received several prestigious early career awards, including an ERC Starting Grant.

Synthesis of Magnetoelectric Nanoparticles via Hydrophobic Layer Deposition of Barium Titanate and their Application in Neuron Stimulation

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³*Soft Matter Nanotechnology Group, CIC biomaGUNE, Basque Research and Technological Alliance. San Sebastian, Spain*

Abstract:

Here, we report a novel method for deposition of piezoelectric Barium Titanate on the surface of

hydrophobic cobalt ferrite nanoparticles. The method relies on interactions between a synthesized Ba and Ti Oleate precursor and the alkyl chains of the ligands surrounding the surface of the material. A deformation of a cubic regime (c/a above 1) in the Barium Titanate layer and a magnetoelectric voltage output in the order of milli volts confirms the multiferroic properties of the core: shell structure achieved. Furthermore, the material was tested *in vitro*, and magnetically induced electrical stimulation of hippocampal neurons cultures were demonstrated via fluorescence microscopy of calcium transients.

Biography:

Dr. Vicente Duran-Toro work as a postdoctoral researcher at the Friedrich-alexander Universität Erlangen-Nürnberg in the Biointerfaces lab. He focusses on the synthesis of magnetoelectric and piezoelectric nanomaterials and how to implement them as nanotransducers in biological systems. Among his current projects he works on how to improve material-biological interfaces in nanochips, specifically, biocompatibility, colloidal stability and development of novel actuation modalities as the converse piezoelectric effect.

Functionalization of 2D Materials and the Development of Nano-Hybrid Platforms for Biosensing and Nanofluidic Applications

Martina Lihter

Centre for Advanced Laser Techniques, Institute of Physics, Zagreb, Croatia

Abstract:

Integrating solid-state materials with biomolecules is essential for creating nano-bio hybrid interfaces and nanostructures necessary for the design of next-generation biosensing and nanofluidic devices. Among the most promising solid-state materials are two-dimensional (2D) transition metal dichalcogenides (TMDs), which exhibit exceptional electronic, optical, and mechanical properties. Their atomic thinness, mechanical strength, and optoelectronic capabilities make them highly versatile for applications in (opto)electronics, catalysis, biosensing, energy harvesting, and more. Combining these unique properties with biomolecules—such as DNA, proteins, aptamers, and enzymes—could enable the development of advanced biosensing, nanofluidic, and molecular transport platforms. For example, attaching biomolecular enzyme motors to nanopore systems could provide dynamic control over the translocation of single molecules across thin membranes. However, a major challenge in developing such hybrid systems is the chemical functionalization of 2D TMD surfaces, which primarily consist of an inert basal plane. Effective functionalization strategies can enable the covalent attachment of chemical functional groups and biomolecules, allowing for the tuning of optoelectronic and surface properties, improving device stability, introducing biochemical recognition, and enhancing ion selectivity.

This talk will focus on the nanofabrication and applications of 2D nanopore sensing devices ^[1-3], as well as selective chemical functionalization strategies ^[4,5] for the creation of future nano-bio hybrid interfaces and nanoscale systems.

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Biography:

Dr. Martina Lihter is a Research Associate in the CALT department at the Institute of Physics in Zagreb, Croatia. She obtained her Ph.D. in Chemistry and Chemical Engineering in 2020 from the École Polytechnique Fédérale de Lausanne (EPFL, Switzerland) while working at the Laboratory of Nanoscale Biology. She conducted her postdoctoral research at the Laboratory for In Situ Nanomaterials Characterization with Electrons (EPFL) and the Max Planck–EPFL Laboratory for Molecular Nanoscience. Her expertise lies in the functionalization and nanoscale engineering of atomically thin, two-dimensional materials for sensing applications. She is currently a HORIZON-MSCA-WIDERA Fellow, leading the 2D-NanoHyb project.

Novel Magnetic Cellulose Nanocomposite Coating as a Potentially Flexible Electronic Material

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³*Technische Universität Braunschweig, Braunschweig, Germany*

Abstract:

Developing promising nanocomposites based on sustainable electronic components is receiving increasing attention from researchers and the industry. A special place is occupied by materials from renewable sources based on nanocellulose, which have great potential as a basis for flexible electronics. The possibility of its combination with ferromagnetic particles opens up great prospects for the subsequent use of a cellulose ferromagnetic composite for a wide range of sensors, markers, data storage devices, etc. The possibility of the coating by a new magnetic nanocomposite based on negatively charged cellulose colloids (1360 $\mu\text{mol/g}$) and positively charged hard magnetic hexaferrite ($\text{SrFe}_{12}\text{O}_{19}$) nanoparticles with a large permanent magnetic moment was demonstrated. Thin nanofilms of the magnetic cellulose composite were obtained by spray deposition on a silicon substrate and studied by microscopic imaging, surface-sensitive X-ray scattering and magnetic determining techniques. Ferromagnetic nanoparticles are uniformly distributed in the cellulose matrix and form a nanocomposite due to the opposite charges of the initial components. Magnetic nanoplates show a predominant orientation parallel to the plane of the substrate, and the resulting nanocomposite has the highest intrinsic coercivity field inherent in the properties of individual nanoparticles. Coatings of magnetic nanopaper with a large coercive field are a promising composite for creating new devices in the future, from materials science to flexible electronics and medicine.

Biography:

Andrei Chumakov is a Scientist at the P03 beamline of the PETRA III synchrotron. He earned a PhD from St. Petersburg University in Russia and later worked as a postdoctoral fellow at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France. His research interests include GISAXS/SAXS, GIWAXS/WAXS, and the investigation of 2D and 3D nanostructures.

Design of Protein-Based Hydrogels Loaded with Graphene

Giulia Quaglia*, and Loredana Latterini

Nano4Light Lab, Department of Chemistry, Biology and Biotechnology, University of Perugia, Italy

Abstract:

Protein-based hydrogels have been widely used in biomedical field for drug delivery^[1], wound dressing^[2], sensing^[3] and in other technological areas like environmental remediation^[4]. Despite their biocompatibility and biodegradability, their applications are limited due to the fragile mechanical properties^[5]. The combination of hydrogels with other materials such as graphene improves their properties and diversifies their functions. Graphene nanostructures have attracted the attention of the scientific community from its isolation in 2004, due to their versatility, the extended surface area, electrical conductivity, chemical and mechanical stability^[6]. In this work, protein-derived hydrogels have been prepared and formulated through cost-effective and sustainable procedures, to achieve transparent matrices. The preparation conditions such as pH, protein concentration and temperature have been changed to tune the physical properties of the hydrogel. Furthermore, graphene flakes have been incorporated into protein-based hydrogels and the final products have been morphologically and optically characterized through several spectroscopic and microscopic techniques. Rheological measures, i.e. temperature ramps, amplitude and frequency sweep, have been carried out to deeper understand how the synthetic parameters and the presence of graphene affect the gelation processes. Regulating graphene loading leads to conductive bio-based hydrogels promising in various projected applications.

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Biography:

Giulia Quaglia holds a Post-Doctoral position at the Nano4Light Lab of the University of Perugia, where she works on the formulation of responsive nanocomposites. She received a BS in Chemistry in 2016 with a thesis on the photoreduction of antimicrobial silver nanoparticles on mesoporous silica, followed by an MS in Chemical Science in 2018, developed in collaboration with the European Laboratory for Non-Linear Spectroscopy. In 2022, she successfully defended a PhD in Biotechnology focused on TTA-upconversion in smart media; her thesis was awarded the “Ugo Mazzucato Award” by the Italian Photochemistry Group-EPA for the best PhD thesis in photochemistry.

Ultra-Fast DC Sputtering of Silver Nanoparticles for Tailored Plasmonic Architectures Without Templates

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Abstract:

We introduce a rapid and reproducible method to fabricate silver nanoparticle monolayers with sub-10 nm diameters using direct current (DC) sputtering. In contrast to chemical and lithographic approaches, our technique enables the formation of densely packed, spatially isolated nanoparticles on dielectric substrates using a two-second deposition under low-power conditions. Electron microscopy analyses (SEM, TEM, HRTEM, STEM) reveal uniform quasi-spherical particles and consistent interparticle spacing, with an average Feret diameter of 8.7 ± 4.8 nm and mean separations greater than 25% of the particle size. This morphology suppresses near-field coupling, preserving distinct localized surface plasmon resonances (LSPR). Optical characterization confirms the emergence of a narrow resonance peak at 460 nm, demonstrating the method's potential for photonic applications requiring precise plasmonic behavior. Structural assessment via high-resolution TEM and FFT confirms the crystalline nature of the particles and identifies the occasional presence of surface Ag₂O layers. Complementary growth simulations verify the sensitivity of particle distribution to deposition parameters such as substrate distance and time, closely matching experimental results. This minimalist fabrication strategy eliminates the need for sacrificial templates, surfactants, or lithographic processing, thus offering a clean and scalable path for generating nanostructured plasmonic platforms. The resulting architectures are well suited for deployment in nanoscale photonic devices, optically integrated sensors, and planar coupling schemes where LSPR control and reproducibility are critical.

Biography:

Arturo Rodríguez-Gómez is a condensed matter physicist at the Institute of Physics, UNAM. He specializes in thin-film nanofabrication and optical characterization of plasmonic and semiconducting nanomaterials. With over 41 JCR-indexed publications and more than 600 citations, his work spans experimental instrumentation and theoretical modeling of optoelectronic systems. He leads the Silicon Photonics Lab, developing custom-built sputtering systems and optical setups. He is a Level II member of Mexico's National Researchers System. Currently, he serves as Head of the Condensed Matter Department at IFUNAM. He is passionate about combining scientific rigor with technological innovation.

Graphene-Si₃N₄ Nanocomposites: From the Powder Synthesis to the Properties

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Abstract:

The dispersion of graphene in a ceramic matrix can lead to composites with interesting physical and mechanical properties. Samples are usually prepared by methods that involve mixing a ceramic powder with more or less defective graphene agglomerates, followed by consolidation by sintering. This results

in a microstructure where platelets of a few layers of graphene (few-layered-graphene - FLG) are dispersed as discrete particles in the ceramic matrix.

However, it is possible to prepare graphene-ceramics powders without mixing, by subjecting a powder bed to a heat treatment causing the decomposition of a carbonaceous gas, which results in the formation of a deposit of few-layer-graphene (FLG), with typically 1-8 layers, around the ceramic grains. Moreover, the microstructure after sintering then consists of a continuous FLG film, located along the matrix grain boundaries, unlike the samples prepared by a mixing route.

Graphene-Si₃N₄ powders and samples sintered by Spark Plasma Sintering are studied by techniques including carbon assays, Raman and XPS spectroscopy, scanning and transmission electron microscopy. The role of the presence of FLG on densification, electrical conductivity, microhardness and mechanical reinforcement will be presented and discussed.

Biography:

Dr. Alicia Weibel is Assistant Professor of Materials Chemistry at Université Toulouse 3 Paul-Sabatier in the Nanocomposites, Carbon Nanomaterials: Elaboration and Densification team of the CIRIMAT (Interuniversity Center for Materials Research and Engineering). Currently, her researches focus on the synthesis and characterisation of carbon nanotubes and graphene ceramic nanocomposites and spark plasma sintering. She has published more than 65 papers in peer-reviewed journals.

Nanomaterials Based on Quinoid Complexes: From Solution to Surface

Olivier Siri

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Abstract:

The rich chemistry of molecules exhibiting a quinoid structure has attracted the interest of a large scientific community for decades owing to their implications in a wide range of applications including in supramolecular chemistry and nanoscience. A critical element in designing and fabricating new nanomaterials is the control of the pi-distribution and the nature of the heteroatoms. 2,5-Diamino-1,4-benzoquinonedimine (DABQDI) is a very long known molecule (1887) that has been poorly investigated owing to its low solubility and its instability in solution. We decided to revisit the chemistry of DABQDI in order to elaborate new materials that are of major interest in many technological sectors. Our strategy is based on: 1) the use of DABQDI as ligand in coordination chemistry both in solution and on metallic surfaces, and 2) the use of DABQDI as building block in supramolecular chemistry for the on-surface construction of (supra)polymers with unusual electronic properties. The different approaches and the key role of the quinoidal precursors will be described and discussed in the presentation. In addition, a closely related molecule will be also reported in order to highlight the crucial influence of the heteroatoms in the construction of large molecular architectures in solution and on surface.

Biography:

Olivier Siri obtained his PhD (1997) in Dijon and then worked as post-doctoral fellow at UC Davis USA; and the University of Neuchâtel (Switzerland). He joined the CNRS in 1999 at the University of Strasbourg and moved in 2005 at Aix-Marseille University. He is currently Director of Research (CNRS) and group leader at CINaM laboratory. He is also deputy director of CINaM (center of Nanoscience). His main

research interests deal with conjugated pi-systems as dyes in photonic, as ligand in coordination chemistry, or as building block in nanoscience. He is an author and co-author of about 130 publications and 15 patent applications, and has given about 100 plenary, keynote, and invited talks.

Synthesis and Characterization of TiO₂ Nanostructures on Ti₂₈Nb₄Sn Alloy via Electrochemical Anodization

José Rodrigo Muñoz Hoyos^{*1}, Cristian Andrés Contreras Rubio¹, Nicolás Suarez Mendoza¹, John Fredy Rios¹, Jazmín Icelly González¹, and Javier Andrés Muñoz Chaves²

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Abstract:

Titanium alloys, particularly Ti₆Al₄V, have been widely used for bone implants due to their excellent biocompatibility. However, recent studies have revealed significant limitations including Young's modulus mismatch with cortical bone, causing stress-shielding effects, and biocompatibility concerns from aluminum and vanadium ions that may cause cytotoxic responses and long-term toxicity. These mechanical and biological limitations have driven research toward developing alternative Ti-based alloys with improved osseointegration and reduced toxicity profiles. The generation of TiO₂ coating structures through anodic oxidation presents a promising solution by creating surface nano-topography that enhances osteoblast adhesion, proliferation, and differentiation while mimicking bone extracellular matrix properties. Additionally, the TiO₂ layer provides corrosion protection in physiological environments. This work investigated nanostructured TiO₂ coatings on Ti₂₈Nb₄Sn alloy through anodic oxidation. Ti₂₈Nb₄Sn samples underwent electrochemical anodization to form TiO₂ coatings, which were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS). SEM characterization revealed TiO₂ nanostructures forming hollow cylinders with internal and external diameters of 41 and 127 nm, respectively, and an estimated height of 673 nm. EDS analysis identified Ti and O in the coating area and Ti, Nb, and Sn in the substrate. XRD results showed only substrate alloy phases, suggesting amorphous TiO₂ phase formation, consistent with literature reports. These findings demonstrate the potential of Ti₂₈Nb₄Sn alloy with TiO₂ coatings as a viable candidate for biomedical applications, offering improved biocompatibility and mechanical properties compared to conventional Ti₆Al₄V alloy.

Biography:

José Rodrigo Muñoz Hoyos is a physicist engineer from the University of Cauca, Colombia, with a master's and doctorate in Materials Science and Engineering from the Federal University of São Carlos, Brazil. His publications in Scopus-indexed journals cover the chemical synthesis and sintering of piezoelectric, magnetic, and magnetoelectric materials. He is currently a professor and researcher at Antonio Nariño University in Bogotá, Colombia. Together with the Comfacaucua University Corporation (UNICOMFACAUCA), he is working on a research project focused on the synthesis and characterization of TiO₂ nanostructured coatings on TiNbSn alloys, with initial results prepared for presentation at the upcoming event.

Light-Driven Skyrmion Crystal Generation in Plasmonic Metasurfaces Through the Inverse Faraday Effect

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Institut des Nanosciences de Paris, Sorbonne Université, CNRS, Paris 75005, France

Abstract:

Skyrmions are topological structures defined by a winding vector configuration that imparts a quantized topological charge. In magnetic materials, these nanoscale spin textures are uniquely stable yet highly mobile, making them central to emerging spintronic devices that demand compactness and low energy consumption. Meanwhile, optical analogs of skyrmions open new frontiers in controlling and directing light at the nanoscale, revealing a promising route toward ultrafast, high-density photonic and magneto-optical technologies.

Here, we demonstrate the generation of a skyrmion-topological lattice by exploiting the inverse Faraday effect (IFE) in a specifically engineered plasmonic metasurface. Designed as a hexagonal array of gold nanodisks, our metasurface supports unidirectional drift photocurrents within each disk, while “phantom” currents flow in the opposite direction through the hexagonal interstices. This interplay of localized currents creates a periodic arrangement of skyrmionic magnetic textures, achieving a large-scale, regular lattice.

Notably, our approach is entirely optical and takes advantage of plasmonic resonances to enhance local electromagnetic fields, thereby maximizing the IFE-induced magnetization. The process is potentially ultrafast, operating on femtosecond-to-picosecond timescales, which holds significant implications for future device architectures. By providing a pathway to integrate skyrmions into nonmagnetic substrates or thin magnetic films, our findings pave the way for advanced data storage and processing solutions that exploit these robust topological features.

Altogether, this study not only validates a new mechanism for creating skyrmions but also demonstrates how the synergy between plasmonics and ultrafast magnetism can expand the limits of existing spintronic and photonic devices. This could accelerate the adoption of skyrmion-based approaches in next-generation memory and logic applications.

Biography:

Mathieu Mivelle is a researcher at CNRS, currently affiliated with the Institut des Nanosciences de Paris (INSP) at Sorbonne Université. Specializing in nanophotonics and plasmonics, his work focuses on manipulating and controlling light at the nanoscale through the design of innovative optical nanoantennas and plasmonic structures. His research not only deepens our understanding of light-matter interactions but also paves the way for applications in sensing, imaging, and quantum technologies.

Engineering Innovative Nanobiosensors with Tunable SERS Hotspots for Ultra-Sensitive Detection of Viral Pathogens in Food and Water

Ojodomo J. Achadu^{1*}, Syuei Maehata², Indra M. Khoris², and Enoch Y. Park²

¹*Teesside University, Middlesbrough, United Kingdom*

Abstract:

The innovative approach to enhance signal detection in surface-enhanced Raman scattering (SERS)-based systems through nanotechnology-based engineering of nanotags is promising. In this work, optical nanotags - consisting of gold (Au) and silver (Ag) core-shell nanoparticles with satellite gold (Au) nanoparticles conjugated with 4-mercaptobenzoic acid (4-MBA) as a Raman tag exhibit significant SERS enhancement, achieving an enhancement factor on the order of 10^8 . This strong enhancement is attributed to the creation of numerous hotspots resulting from the combination of core-shell nanoparticles and satellite AuNPs on the Au@Ag-MBA surfaces. When incorporated into a compact Palmtop Raman spectrometer, the nanotags enabled concentration-dependent SERS intensity, of norovirus – a food or water-borne pathogen. Ultra-sensitive detection of the virus across a range of 10 fg/mL to 100 pg/mL of norovirus-like particle (NoV-LP) samples were observed, with a detection limit of 0.76 fg/mL. Remarkably, even in complex matrix environments, the coefficient of variation remained below 10%, and the detection system demonstrated approximately 10^7 times higher sensitivity than commercial ELISA kits. Additionally, norovirus in clinical samples was detectable over a broad concentration range of 1.0×10^1 to 1.0×10^6 RNA copies/mL, with a detection limit of 7.8 RNA copies/mL, offering sensitivity comparable to real-time PCR. These findings suggest that the developed SERS-based detection system is robust, stable in complex matrices, and has strong potential for detecting food and waterborne viral pathogens in clinical settings using a portable Palmtop Raman spectrometer.

Biography:

Dr. Ojodomo Achadu is an Assistant Professor and Course Leader (B.Sc Chemistry Programme) at Teesside University. He earned his Ph.D. in Chemistry from Rhodes University. His research focuses on engineering innovative functional nanomaterials for diagnostic nanobiosensors, water technology, and energy harvesting, underpinning the health-water-environment-energy nexus.

Molecularly Imprinted Polymer for IL-6 Using Conductive Nanomaterials

Ana Rita Cardoso*, Miguel Sousa, Ana Rita Cardoso, Liliana P. T. Carneiro, and Maria Goreti F. Sales

BioMark, CEMMPRE, ARISE, Department of Chemical Engineering, Faculty of Sciences and Technology, University of Coimbra, Coimbra, Portugal

Abstract:

This work deals with the development of a conductive and catalytic ink using a high frequency ultrasonic method to be used as a substrate for a molecularly imprinted polymer (MIP) for IL-6 at the anode of a fuel cell. The conductive ink was prepared by mixing carbon black (CB), platinum (Pt) and palladium (Pd) nanoparticles, resulting in a CB-PtPd-based dispersion. It was prepared with a suitable binder and solvent (isopropanol) and cast onto the working electrode of screen-printed electrodes (SPEs).

The MIP layer was then anchored in situ on the SPE/CB-PtPd electrodes with the monomer 3,4-ethylenedioxythiophene (EDOT). This monomer was chosen for its excellent conductivity properties and its ability to form uniform, well-defined films and is also compatible with fuel cells. The optimal conditions for the design of the MIP layer on SPE were evaluated and adapted for possible integration into a direct glucose fuel cell electrode. The analytical performance of the electrode was analysed in

phosphate buffer pH 7.4 with standard solutions ranging from 1.0 pM to 10 μ M. In parallel, the control (non-imprinted polymer, NIP), was tested with the same concentrations and the higher selectivity of the MIP film was confirmed. Further tests are underway and are aimed at the integration of this material into the glucose-based fuel cell.

Acknowledgements: The SENSOPAD project has received funding from the European Union's Horizon Europe Research and Innovation Programme under grant agreement n° 101130516.

Biography:

Rita Cardoso graduated from the Polytechnic Institute of Porto with a degree in Health Biochemistry. She recently completed her PhD at NOVA in Lisbon in the Nanosciences and Nanotechnologies programme (January-2024). She did her research at BioMark@UC in Coimbra. Her PhD thesis focused on the development of catalytic and conductive nanomaterials for the health field, especially for the detection of some important cancer biomarkers. Her background is related to electrochemical systems, in particular plastic antibodies and (bio)sensor platforms. In addition, she has a solid foundation in electrochemical devices and the synthesis and characterisation of conductive nanomaterials used in various fields.

Eco-Design of Porous Silica Adsorbents

Ivalina Trendafilova*, and Margarita Popova

Institute of Organic Chemistry with Centre of Phytochemistry, Bulgarian Academy of Sciences, Sofia, Bulgaria

Abstract:

Over the past two decades, porous silica materials have demonstrated exceptional adsorption capabilities for efficient molecular storage, separation, and isolation. However, their industrial application remains limited due to the high costs and environmental concerns associated with their synthesis. Conventional porous silica synthesis relies on expensive and toxic templates, hydrothermal synthesis, and high-temperature template removal processes. To facilitate their integration into industrial applications, sustainable and eco-friendly synthesis must be developed. Key considerations for achieving this goal include: i) Use of biodegradable, reusable, and low-cost porogens; ii) Optimization of synthesis and template removal conditions; and iii) Utilization of natural sources and industrial waste as silica precursors.

This study presents a simple and environmentally friendly approach for synthesis of porous silica materials. Herein, as an alternative to the conventional porogens, carboxylic acids (citric, ascorbic, etc.) were employed, and as a natural silica source biomass waste from rice husk was utilized. The synthesis was conducted at low temperatures (up to 60°C) in water, minimizing the environmental impact and the cost of the final material. Template removal was achieved *via* water extraction at room temperature, and the porogens were regenerated.

To clarify the influence of the synthesis procedure on the properties of the final material, thoroughly characterization using XRD, NMR, N₂ physisorption, and TGA was conducted on each synthesis stage. The results showed the formation of mesoporous silicas with surface area up to 1000 m²/g and varied pore structure. To assess the adsorption capacity of the obtained materials they were further functionalized with amino groups for CO₂ adsorption or with metal species for adsorption and separation of natural bioactive molecules.

The obtained silica demonstrated exceptional efficiency comparable to conventional adsorbents. These findings highlight the potential of the developed synthesis approach for the preparation of sustainable porous silica as a versatile platform for high-performance adsorbents.

Biography:

Dr. Ivalina Trendafilova is a Research Fellow at the Bulgarian Academy of Sciences (BAS), leading the SAND project under the National Scientific Program “Petar Beron i NIE.” She has completed long-term postdoctoral research at Namur University, Belgium, and the National Institute of Chemistry, Slovenia, along with internships in France, Bulgaria, and the USA. Holding a PhD in Chemistry from BAS and an MSc in Medicinal Chemistry from Sofia University, her research focuses on sustainable mesoporous silica for catalysis, adsorption, and biomedical applications. She has authored 25 research papers, contributed to multiple EU-funded projects, and received numerous national and international awards.

Smart Solutions for Liquid Purification: Porous Materials for Water and Oil

Sunny K. S. Freitas^{1*}, Leticia C. Correa^{1,2}, Pierre M. Esteves², and Luis C. Branco¹

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Abstract:

The use of porous materials for liquid purification has emerged as a practical and efficient strategy across various applications. Their structural robustness enables the selective removal of contaminants and supports multiple regeneration cycles. Traditionally, materials such as activated carbons and bioceramics have been employed as adsorbents in water treatment systems. However, their limited ability to remove trace levels of organic pollutants and heavy metals has driven the search for more advanced alternatives. In this context, Covalent Organic Frameworks (COFs) have attracted increasing attention due to their highly tunable porosity, large surface areas, and structural versatility. These features allow for the design of application-specific frameworks that can achieve high adsorption capacity and selectivity, particularly in the treatment of contaminated water.

Beyond water, another challenging fluid to purify is oil, especially when purity must be preserved for food-grade applications. Insect oils, when obtained through mechanical extraction, often contain pigments and bioactive compounds that give them a dark appearance, limiting their direct use in the food industry. Removing these compounds without degrading the oil's nutritional properties requires selective and mild purification methods. To address this, porous materials such as ZSM-5 zeolites and neutral alumina have shown promise in refining oils by adsorbing unwanted impurities while preserving essential components. Their physical and chemical properties make them suitable for food-safe decolorization and purification processes.

This work presents a comprehensive overview of the use of engineered porous materials in the purification of both aqueous and oily liquids. By tailoring pore structure, surface chemistry, and adsorption properties, these materials represent a powerful platform for developing sustainable and efficient separation technologies in both environmental and food sectors.

Biography:

She has a degree in Chemistry (IFCE, Brazil), a master's degree in Chemistry (UFRJ, Brazil) where she started to work with porous nanomaterials, and a Ph.D. in Chemistry (UFRJ, Brazil) when she dedicated to building ionic porous materials for environment and energy purposes, being advised by Prof. Dr. Pierre M. Esteves. She currently has a post-doc position at NOVA School of Science and Technology (Lisbon), where she has developed pre-designed porous materials for biosystems purification (water, air, oil) and solid electrolytes. She has published 9 papers in international journals, being considered “hot papers” and “top 10” (Wiley, ACS, IOP, RSC).

Carbon Dots Powering Innovation in Health and Environment

Gil Gonçalves^{1,2}

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²*Intelligent Systems Associate Laboratory (LASI), Guimarães 4800-058, Portugal*

Abstract:

Carbon-based nanomaterials have emerged as highly promising platforms for addressing complex challenges in both biomedical and environmental technologies. Their scientific importance is underscored by two landmark Nobel Prizes: the 1996 Prize in Chemistry for the discovery of fullerenes and the 2010 Prize in Physics for the discovery of graphene. These milestones accelerated progress in carbon nanoscience and broadened its impact across research and society. Carbon nanomaterials exhibit diverse morphologies, chemical compositions, and tunable physicochemical properties, enabling the development of advanced hybrid nanostructures tailored for specific applications.

Among these materials, carbon dots (CDs) have attracted particular attention due to their ultra-small size (<10 nm), chemical versatility, and tunable optical behavior.^[1] Their exceptional biocompatibility, low toxicity, and strong photoluminescence make CDs especially promising for biomedical applications. Recent studies, including work from our group, demonstrate the potential of functionalized carbon-based nanomaterials in tissue engineering, cancer therapy, and diagnostics. In cancer treatment, CDs stand out for their adjustable fluorescence and highly versatile surface functionalization, offering exciting opportunities for bioimaging, targeted drug delivery, and photodynamic therapy.^[2]

Beyond biomedicine, CDs also present significant potential in environmental applications.^[3] Their remarkable ability to adsorb heavy metals, dyes, and other pollutants supports their use in advanced water purification technologies. Moreover, their fluorescence sensitivity to specific contaminants enables selective detection of heavy metals, pesticides, and persistent organic pollutants, highlighting their value as environmental sensors.

This presentation will showcase recent contributions from our research group in designing functionalized CDs and expanding their use in cancer therapy, diagnostics, and environmental remediation, emphasizing their growing role in tackling global scientific and societal challenges.

References:

[1] Gonçalves G. et al. *Nanoscale*, 2025, 17, 12554-12579

[2] Gonçalves G. et al. *ACS Appl. Nano Mater.* 2021, 4, 13079–13089

Biography:

Gil Gonçalves graduated in Chemistry and earned his Ph.D. in Mechanical Engineering from the University of Aveiro. In 2016, he joined the Institute of Materials Science of Barcelona (ICMAB-CSIC), where he advanced research in neutron capture therapy. He has also been a visiting researcher at the Laboratory of Applied Nuclear Energy (University of Pavia) and at the Department of Chemical and Pharmaceutical Sciences (University of Trieste). He currently leads a dynamic Micro- and Nanofabrication research group at the Center for Mechanical Technology and Automation (TEMA), University of Aveiro. His work focuses on the development of innovative hybrid carbon-based nanomaterials for cancer therapy, bioimaging, and environmental applications. His team also advances cutting-edge strategies in pharmacological microfluidic fabrication and is at the forefront of developing next-generation tumor-on-chip platforms.

Effect of Graphene Additives on the Physical and Mechanical Properties of Zirconium Dioxide

Edvin Hevorkian^{1*}, Mirosław Rucki², Leszek Chalko², Waldemar Samociuk¹, Dmitrij Morozow², and Volodymyr Chishkala³

¹*University of Life Sciences in Lublin, Lublin, Poland*

²*Casimir Pulaski Radom University, Radom, Poland*

³*V. N. Karazin Kharkiv National University, Kharkiv, Ukraine*

Abstract:

Partially stabilised yttrium oxide zirconia has a wide range of applications as a structural material and is also widely used in medicine as a material for dental prostheses and bones. The addition of graphene nanopowders in small amounts affects the physical and mechanical properties of zirconia obtained by hot pressing with the passage of high amperage electric current, electroconsolidation. The powder mixture for the study was prepared in a special planetary mill Pulverisate7 by mixing ZrO_2 -3 mol/% Y_2O_3 nanopowders with graphene nanopowders with particle size 11-15 nm. The investigated nanocomposite materials were obtained at different sintering temperatures $T=1200$ - 1400 °C, pressure 45 MPa and holding time at final temperature 2-3 min. The microstructure, phase composition, density, hardness and strength, tribological properties of the obtained samples, as well as the kinetics of the sintering process of nanopowder mixtures and its peculiarities were investigated. The studies show that graphene additives, even in small amounts, reduce the coefficient of friction of composites, improve the microstructure, hardness and strength. It was found that to obtain a homogeneous structure of the composites, it is sufficient to mix the powders at a speed of 800 rpm and a holding time of 60 min. In order to obtain samples with higher properties, it is necessary to study samples with different contents of graphene additives and with different sintering modes. Optimization of sintering modes and mixture composition will allow to achieve higher values of mechanical properties.

Biography:

Prof. Edvin Hevorkian scientific interests are compatible with research directions, realized in the University of Life Sciences in Lublin (Poland). E. Hevorkian is mainly interested in the research on the composite materials of various applications, including cutting tools, with focus on the nanostructural features, sustainability, and functionality. Hevorkian's scientific activity was always connected with

various composite materials and their processing aimed to gain fine micro- and nanostructures with enhanced properties. Among total number of 420 papers, he managed to publish 380 scientific articles and 40 reports in conference proceedings. He authored and co-authored more than 60 patents, among them 1 US patent and 1 UE patent.

Young Researchers Presentations

Reductant Assisted Hydrothermally Synthesized Ni-Fe Based Magnetic Nanoalloys for Tunable Magnetization

Aiswarjya Bastia*, and Chandana Rath

School of Materials Science and Technology, Indian Institute of Technology (BHU), Varanasi, Uttar Pradesh, 221005, India

Abstract:

A template-free, reductant-assisted hydrothermal method has been employed for the first-time to synthesize compositionally and magnetically tunable Ni_{1-x}Fe_x (x = 0.25, 0.5, and 0.75) nanoalloys. The structural evidences from X-ray diffraction (XRD) patterns while confirm a single phase Face Centered Cubic (FCC) structure for x = 0.25 and 0.5, coexistence of 90.53% FCC and 9.47% Body Centered Cubic (BCC) are identified for x = 0.75. High-resolution scanning electron microscopy (HRSEM) demonstrates the particle size in the nano regime with reasonable chemical homogeneity of the alloys. From X-ray photoelectron spectroscopy (XPS), we observe the metallic Ni and Fe along with partial surface oxidation. Field dependent magnetization measurements reveal well saturated hysteresis with high saturation magnetization (M_s) of 0.94, 1.59, and 0.86 μB/f.u. for x = 0.25, 0.5 and 0.75 respectively compared to bulk alloys. Such high M_s is well explained by itinerant electron model showing a good agreement between experiment and theory. The composition dependent change in magnetization aligns with Slater-Pauling behavior and confirms the invar effect. Further, the fit of M_s to Law of Approach to Saturation (LAS) estimates the effective anisotropy (K_{eff}) as 230, 760, and 430 kJ/m³ for x = 0.25, 0.5 and 0.75 respectively. The observed tunability of magnetization, along with low hysteresis loss, highlights the potential of these soft magnetic nanoalloys for applications in magnetic sensors and data storage technologies.

Reference:

A. Bastia, C. Rath, Reductant Assisted Hydrothermally Synthesized Ni-Fe Based Magnetic Nanoalloys for Tunable Magnetization, J Magn Magn Mater 630 (2025) 173335. <https://doi.org/10.1016/j.jmmm.2025.173335>

Biography:

Aiswarjya Bastia is a research scholar at the School of Materials Science and Technology, Indian Institute of Technology (IIT) BHU, Varanasi, India. The research focuses on the design and development of advanced functional materials, with particular interest in magnetic nanoalloys, magnetostrictive and bioactive composites, and their applications in data storage and biomedical fields. Expertise includes synthesis, structural and magnetic characterization, as well as first-principles simulations. Aiswarjya Bastia has presented work at several national and international platforms and is currently engaged in interdisciplinary research aimed at addressing real-world materials challenges.

MXene-Reinforced Carrageenan/PVA Nanocomposite Films with Advanced Functionalities for Sustainable Packaging Applications

Hongna Yuan*, Ming Dong, and Dimitrios G. Papageorgiou

School of Engineering and Material Science, Queen Mary University of London, London, United Kingdom

Abstract:

In response to an ever-growing demand for sustainable packaging solutions, this work investigates the critical role of natural polymer kappa carrageenan (KC) and polyvinyl alcohol (PVA), in constructing multifunctional nanocomposite films reinforced with MXene for eco-friendly packaging applications. KC/PVA films containing varying amounts of $\text{Ti}_3\text{C}_2\text{T}_x$ MXene (0.5-7.5 wt%) were fabricated via a simple solution casting method. The impact of MXene nanoplatelets on produced films' chemical structure and physicochemical properties was systematically evaluated. Benefiting from their two-dimensional geometry, the incorporation of MXene nanoplatelets into the KC/PVA matrix promoted the formation of an ordered microstructure, as revealed by SEM. This is attributed to the planar morphology and strong interfacial interactions of MXene within the polymer network. Notably, the produced films exhibited significant enhancements in mechanical properties and barrier performance with increasing MXene loading. At 5 wt% MXene, the Young's modulus and tensile strength increased by 315% and 108%, respectively. The presence of MXene induced superior water vapour barrier capabilities, reducing permeability from 3.6×10^{-10} to 0.6×10^{-10} g/m $\cdot$ Pa $\cdot$ s at the same MXene content. The nanocomposites displayed improved hydrophobicity compared to the neat polymer films that contributed to better water resistance and reduced moisture uptake, indicating potential self-cleaning behaviour. Furthermore, the KC/PVA-MXene nanocomposite films displayed promising recyclability and biodegradability, demonstrating their potential as renewable and recyclable multifunctional packaging materials. By integrating MXene into carrageenan and PVA matrices, these bio-based nanocomposites offer a compelling combination of environmental sustainability and improved mechanical and barrier properties, aligning with the increasing demand for eco-conscious packaging solutions.

Biography:

Hongna Yuan is currently pursuing a PhD at Queen Mary University of London, specialising in sustainable and functional applications, with a particular focus on developing bio-based nanocomposites using natural polymers and advanced nanomaterials like MXene. Building on this foundation, Yuan is also actively exploring opportunities to extend this research toward the design and fabrication of intelligent sensor systems. With a strong commitment to sustainable innovation, Yuan aims to bridge advanced materials science and sensing technologies to address key challenges in environmental sustainability and intelligent sensing applications.

Transport of Micrometer Sized Chips with Patterned Liquid Micro Rails

Pedro H. O. Moreira^{1,2*}, Johannes Reiprich^{1,2}, Nishchay A. Isaac^{1,2}, Bardia Aliabadian^{1,2}, Guilherme J. Vernizzi³, and Heiko O. Jacobs^{1,2}

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²Zentrum für Mikro- und Nanotechnologien, Technische Universität Ilmenau, Ilmenau, Germany

Abstract:

In microelectronics industry, integration, transport and alignment of microscopic chips are important steps with common approaches being pick-and-place, microfluidics, parallel transfer and self-assembly. In this work, an alternate transport approach of microscopic chips is proposed using patterned liquid micro rails as chaperones capable of guiding chip motion in a user defined fashion. Interfacial free energy minimization enables the creation of a stable bond between transported chips and the liquid rail. The liquid layer lubricates chip-sliding along the rails, while the bond keeps the chips attached to the rail during transport. Monorails, digital monorails, and digital birails are investigated for chip movement behavior. Chip position and speed can be controlled using liquid flow inside closed chambers as a driving force. Speeds from 10 to 400 mms⁻¹ are achieved with translation distances as long as 50 mm. It is discovered that, through the formation of temporary liquid bridges, chips can selectively cross rail discontinuities of up to 500 µm, with longer discontinuities requiring higher driving forces to be crossed. This dependence allows for chip position control through a stop-and-go motion. A programmable liquid rails-based chip conveyor system is showcased by transporting diodes to receptor sites where they undergo self-assembly.

Biography:

Pedro H. O. Moreira has obtained his Mechatronics Engineering degree from the University of Sao Paulo, Brazil in 2019. Currently, he is a scientific researcher at the department of nanotechnology at Technische Universität Ilmenau. He is pursuing a doctoral degree in the area of liquid metal based fluidic self-assembly of microscopic chips.

Design Evolution of Pillar[5]arene-Based Nanopores: From Dynamic Control to High Sensitivity Sensing

Kharina J. Fenton^{1,2*}, Javid A. Malla^{1,2}, Charlie T. McTernan^{1,2}, and Mark. I. Wallace¹

¹*King's College London, London, United Kingdom*

²*The Francis Crick Institute, London, United Kingdom*

Abstract:

Artificial nanopores offer significant potential for drug delivery, biosensors and synthetic biology applications by enabling controlled molecular transport across lipid membranes. Previous efforts have primarily focused on designing water-soluble macrocyclic ion channels for therapeutics, requiring spontaneous membrane insertion and aqueous compatibility. However, nanopore sensing requires different design criteria where stable, low-noise scaffolds with irreversible membrane insertion under physiological conditions are essential. The challenge lies in engineering robust, programmable channels that can simultaneously achieve controlled molecular delivery and high sensitivity sensing, opening new possibilities for advancing precision medicine and biotechnology applications.

Here, we developed pillar[5]arene-based macrocyclic scaffolds through design iterations guided by molecular dynamics simulations, advanced experimental synthesis and electrophysiological characterisation techniques to target these major limitations. Our strategy progressed from stability enhancement through anchoring strategies, and the incorporation of photoswitchable units for dynamic

control. This evolution from basic membrane insertion to sophisticated stability optimisation has resulted in functional systems capable of guest binding and translocation at a single-molecule level, characterised through single channel recordings in droplet interface bilayers.

Biography:

Kharina completed her undergraduate degree in chemistry at Cardiff University, followed by a master's degree in 2020. During a placement year in Australia, she gained valuable experience at the intersection of computational science and synthetic chemistry, working on 3D bioprinting applications for organ prototypes. She now applies this interdisciplinary background towards engineering a new class of artificial channels for biotechnological applications.

Advances in MOF-Based Magnetic Composites and MOF-Derived Nanomaterials: Synthesis and Catalysis

Priyanka*, Anju Srivastava, and R. K. Sharma

Green Chemistry Network Centre, Research Centre, Hindu College, University of Delhi, New Delhi-110007, India

Abstract:

Metal-organic frameworks (MOFs) have gained widespread recognition as versatile materials for catalysis due to their high porosity, tunable structures, and large surface areas. Recent research has led to the development of MOF-derived nanomaterials, including porous carbons, metal oxides, and metal-based composites. These nanomaterials exhibit superior catalytic properties attributed to their precise control over composition and pore architecture, making them highly effective for applications in heterogeneous catalysis, energy storage, and environmental remediation. Among these innovations, MOF-based magnetic composites represent a promising category, integrating the intrinsic porosity and tunability of MOFs with the magnetic properties of nanoparticles like magnetic metal oxides. These composites enable efficient separation and recovery of catalysts through external magnetic fields, a crucial advantage for scalable industrial catalytic processes. Moreover, the incorporation of magnetic nanoparticles into MOFs significantly enhances the thermal and chemical stability of these hybrid materials, addressing limitations commonly associated with pristine MOFs, such as low mechanical strength and challenges in post-catalysis separation. Our work presents a detailed exploration of the latest advancements in the synthesis and catalytic applications of MOF-derived nanomaterials and their based magnetic composites, especially in the field of organic transformations.

Biography:

Priyanka is a faculty member in the Department of Chemistry at Miranda House, University of Delhi, and a Ph.D. scholar at Hindu College, University of Delhi. Her research focuses on developing innovative nano-catalysts for pharmaceutical synthesis and water pollution remediation, aligned with green chemistry principles. She specializes in green chemistry, heterogeneous catalysis, nano-catalysis, and metal-organic frameworks. Skilled in advanced analytical techniques, experimental design, and scientific communication, Priyanka is an active member of the American Chemical Society, Royal Society of Chemistry, and National Environmental Science Academy. She is committed to impactful scientific research and fostering academic excellence.

Symposium IV: Future Materials for Energy, Environment and Sustainability

Featured Presentations

Super-Emitting and Porous Materials for Applications in Energy-Water-Air Nexus

Primož Poredoš

University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana, Slovenia

Abstract:

The world faces a critical challenge in curbing global temperature rise, achievable through substantial cuts in carbon dioxide and greenhouse gas emissions. Yet, amid efforts to lower energy use, the growing threat of agricultural and ecological droughts impacting food production is often ignored, a reality with a worsening outlook. Energy systems are nearing a transformative shift, targeting efficient, sustainable heating, ventilating, and air-conditioning (HVAC) and fresh water generation (FWG) in water-scarce regions. This drives research in material science and thermal engineering, spotlighting sorption and radiative cooling (RC) technologies for next-generation air and water solutions.

ADVANCED ENERGY MATERIALS:

Advanced energy materials like sorbents and radiative sky cooling materials are paving the way for sustainable cooling and FWG. Sorbents, solid hygroscopic porous materials with large surface areas, exhibit high water uptake and come in physical, chemical, composite, and polymeric forms. Radiative sky cooling materials enable daytime sub-ambient cooling by reflecting sunlight in the 0.3-2.5 μm range and emitting heat in the 8-13 μm atmospheric window.

FRESH WATER GENERATION:

For fresh water generation, sorption-based methods involve five steps: capturing water molecules under low temperature and high humidity, releasing them via heat, cooling the vapor to its dew point, condensing it into liquid, and collecting the droplets. In contrast, RC-based FWG simplifies this process into three steps: cooling humid air with RC properties, condensing the vapor, and collecting the water.

SUSTAINABLE COOLING:

Air conditioning, which consumes 10% of global electricity, faces inefficiencies from dehumidification, with cooling-related emissions projected to quintuple by 2050. Research into next-generation systems highlights energy-saving potential, such as using desiccant-coated heat exchangers to separate dehumidification from cooling, reducing temperature differences. RC materials also offer passive cooling, with scalable roof coatings and subambient water cooling applications demonstrating real-world viability. These innovations are key to addressing energy and water challenges sustainably.

Biography:

Assist. Prof. Poredoš finished his PhD in 2015. After PhD, he gained extensive experience in thermal engineering, heat and mass transfer, refrigeration, heat pumps, and mathematical modeling. In 2021, he began his postdoctoral research at the Institute of Refrigeration and Cryogenics, Shanghai Jiao Tong University. There, he gained expertise in adsorbent and radiative cooling materials, their fabrication, characterization, and system integration. At the University of Ljubljana, he is currently the PI of three projects in the fields of multicyclic continuous radiative cooling- and adsorbent-based atmospheric water harvesting as well as solar- and waste heat-driven multistage membrane distillation.

Sulfur Tuned Advanced Carbons: Towards Subtle Modifications of Sulfur Lining

Teresa J. Bandosz*, and Paola Pauletto

Department of Chemistry and Biochemistry, The City College of the City University of New York, New York, NY 10031, United States

Abstract:

Recently a novel method of controlled sulfur insertion to carbon pores has been introduced leading to sulfur-tuned advanced carbons (STACs). In this environmentally benign approach melted sulfur enters the pores owing to their hydrophobic character and external pressure provided by steam (SASI steam-assisted sulfur insertion). When carbon blacks with very limited surface groups were used as sulfur hosts, elemental sulfur directly lined the carbon pore surfaces, gradually filling the pores (from small to large) and its significant amount was the monoclinic γ phase. To investigate the effects of carbon surface groups on sulfur penetration and its forms, the carbon host was oxidized, and then it was impregnated with urea and heated at elevated temperatures to introduce nitrogen-containing groups to the carbon matrix. This treatment also slightly affected the porosity of the sulfur host. The amount of sulfur inserted to the pores was adjusted taking into consideration the specific pore size distributions of the host. Even though at high sulfur contents the materials show similar properties governed mainly by elemental sulfur deposited in the pores, at low loadings, differences in interface chemical environment were found. It was linked to the reactions of small sulfur fragments with surface groups. The introduced chemical heterogeneity was found as affecting catalytic decomposition of toxic CEES.

Biography:

Dr. Bandosz is a Distinguished Professor of Chemistry and Chemical Engineering at the City College of New York. Her work during last 30 years resulted in 7 US patents and over 449 publications in peer-reviewed journals. Since 2014 she is a coeditor of Journal of Colloid and Interface Science. She serves at the Advisory Board of American Carbon Society, and was on the Board of Directors of International Adsorption Society. She is a Fulbright Senior Scholar, Fellow of the American Carbon Society and the International Adsorption Society, Dresden Fellow, and Fellow of the Japan Society for the Promotion of Science.

Ab Initio Study of Reaction Kinetics Occurring at the Surface of SrFeO₃-Based SOFC/SOEC

M.I. Trioni^{1*}, F. Cargnoni¹, M. Viviani², and L. Giordano³

¹National Research Center of Italy (CNR), SCITEC, Milano, Italy

²National Research Center of Italy (CNR), ICMATE, Genova, Italy

³University of "Milano-Bicocca", Dept. of Material Science, Milano, Italy

Abstract:

Unlocking the potential of Solid Oxide Fuel/Electrolysis Cells (SOFC/SOEC) hinges on mastering the reaction mechanisms and kinetics at solid-gas interfaces on their electrodes. By lowering operational temperatures, we can mitigate parasitic reactions that undermine stability and lifespan, while expanding the spectrum of viable materials. Reaction kinetics are shaped by thermodynamic parameters like gas partial pressure and temperature, but they are profoundly influenced by the nature and availability of

active sites. Crucially, electrode reactions involve charge transfer between adsorbed species and the solid electrode, making the applied electric potential a pivotal factor in overall kinetics. This study presents results on the interaction of H₂O and CO₂ with the SrFeO₃(110) surface, obtained by a first-principles theoretical approach, revealing the impact of the aforementioned factors. Key insights include: i) the reversal of reaction direction for charged surfaces, ii) the identification of an optimal working temperature, and iii) the critical role of oxygen vacancies.

Biography:

Mario Italo Trioni, researcher at CNR-SCITEC, bachelor's degree and Ph.D. in Physics at the “Università degli Studi” of Milano. His main research interests are related to theoretical ab-initio study of solid surfaces and molecule-surface interaction with focus on the magnetic, electronic, and electron transport properties. He is author of more than hundred publications. Other topics of interest are low dimensional carbon systems (graphene, nanoribbon and nanoflakes) and defective oxide surfaces.

Hidden Aspects of Solid-State Reactions - View Under the Hood

Nikola Biliškov

Ruder Bošković Institute, Zagreb, Croatia

Abstract:

Fundamentally, any chemical reaction requires mobility of reactant molecules to allow their collisions. However, it is evident that chemical reactions happen even in solid state, where the mobility of chemical species is inherently restricted. Detailed monitoring of mechanochemical reactions recovers regular appearance of amorphous phases in their initial stages, which could play a crucial role enabling solid-state reactions. On the other hand, it is clear that solid-state chemical reactions are initiated by the contact of two substances and take place on the interface. In this line, this presentation is focused to our recent spatially and temporally resolved monitoring of solid-state reactions by means of synchrotron PXRD and microspectroscopic techniques. The emphasis will be on details of the processes and their dynamics in the mechanochemical conditions, as well as during the reactions on solid-solid interfaces, i.e. in the contact zone between two solid reactants. Finally, a comparative analysis of the results, which resolve individual processes enabling solid-state reactivity will be discussed.

Biography:

Nikola Biliškov is currently employed as a senior research associate at the Division of Materials Chemistry of the Ruder Bošković Institute in Zagreb, Croatia. His research is focused on mechanisms of solid-state reactions and intermolecular interactions. In his research, he extensively uses vibrational spectroscopies and powder X-ray diffraction, including synchrotron sources to understand physical and chemical processes underlying reactivity in the solid state. He was a visiting researcher at the EMPA, Switzerland and a Marie Skłodowska Curie fellow at the McGill University in Montreal, Canada.

Removal of Azo Dyes from Water Using Carbon Based Material - A DFT Study

Eva Scholtzova*, and Peter Škorňa

Institute of Inorganic Chemistry, Slovak Academy of Sciences, Bratislava, Slovakia

Abstract:

Azo dyes, synthetic organic compounds, are widely used in textiles, printing, and pharmaceutical industries. They should possess a high degree of chemical and photolytic stability to be useful. As a result of this stability, photolysis is not considered a degradation pathway for azo dyes. Due to this high chemical stability and extensive usage, they are severe environmental pollutants, especially in wastewater. Thus, another effective method of azo dye immobilisation or removal is appreciated. This study investigates the removal of azo dyes from aqueous solutions using a graphene mesoporous sponge (GMS), a high-surface-area, sponge-like mesoporous structure predominantly composed of single-layer graphene walls with active sites for dye adsorption.

Theoretical comparative study of adsorption of two azo dyes, Methylene Blue (MB) and Congo Red (CR), on the graphene (pristine, G6) and modified graphene by 5,7-membered rings simulating defects (G57) in the real GMS structure was done to elucidate the adsorption efficiency of GMS material. This efficiency could enhance the process's economic feasibility and contribute to environmental sustainability by reducing the carbon footprint associated with adsorbent synthesis. The results indicate that GMS is a promising material for wastewater treatment. The analysis of present interactions in the azo dye-adsorbent structures and the calculated adsorption energies (MB dye: -41.0 kJ/mol for MB-G6 and -112.1 kJ/mol for MB-G57, and for CR dye: -267.7 kJ/mol for CR-G6 and -292.5 kJ/mol for CR-G57) clearly favour the GMS material for effective removing MB and CR azo dyes from the environment.

Acknowledgements: Funded by the EU Next Generation EU through the Recovery and Resilience Plan for Slovakia under project No. 560 09I03-03-V04-00009.

Biography:

Dr. Eva Scholtzova has a PhD in physical chemistry. She works in the Department of Theoretical Chemistry at the Institute of Inorganic Chemistry, Slovak Academy of Sciences in Bratislava, Slovakia. Her group studies mainly inorganic layered structures (clay minerals, graphene, and hybrid structures based on them) by molecular modelling and computational methods.

Boosting Cathodes for Next-Gen Sodium-Ion Batteries through Interface Engineering with *In Situ* Electropolymerized PEDOT

Rafael Klee^{1*}, Alejandro Díaz-Martín¹, Luz Sánchez-Silva², and José L. Tirado¹

¹Universidad de Córdoba, Córdoba, Spain

²Universidad de Castilla-La Mancha, Ciudad Real, Spain

Abstract:

This study presents *in situ* electropolymerized poly(3,4-ethylenedioxythiophene) (PEDOT) coatings as a powerful strategy to boost the performance of $\text{Na}_3\text{V}_2(\text{PO}_4)_3$ (NVP) cathodes for sodium-ion batteries. Bare NVP and *in situ* carbon-coated NVP were employed as reference systems, enabling a clear evaluation of the impact of the PEDOT layer. *In situ* electropolymerization was successfully achieved and confirmed by scanning electron microscopy, Raman spectroscopy, and differential scanning calorimetry, while X-ray diffraction verified the full preservation of the crystalline NVP structure throughout the process. Electrochemical characterization highlights the ability of PEDOT to enhance electronic conductivity and accelerate Na^+ -ion transport kinetics across the electrode-electrolyte interface. The combination of *in situ* carbon and PEDOT coating delivered outstanding electrochemical properties: a reversible capacity

over 200 mAh·g⁻¹ at C/10, a high-rate capability of 80 mAh·g⁻¹ at 10C, and 87% capacity retention after 100 cycles at 1C (170 mAh·g⁻¹). Electrochemical impedance spectroscopy demonstrated that the PEDOT coating provided lower charge-transfer resistance and promotes the formation of a stable electrode-electrolyte interface. This dual function establishes PEDOT as both a highly conductive network and an efficient protective barrier, ensuring reliable long-term cycling. Altogether, these findings position PEDOT electropolymerization as a highly effective approach for interface engineering of polyanionic cathodes. By combining structural stability, enhanced charge transport, and interfacial robustness, PEDOT coatings open a practical pathway toward high-performance sodium-ion batteries with superior energy delivery and durability.

Biography:

Dr. Rafael Klee is a materials scientist specializing in energy storage, with expertise spanning solid-state chemistry, nanomaterials, and electrochemistry. After completing his PhD at Universidad de Córdoba on sodium-ion battery electrodes, he gained international experience through academic, industrial, and EU-funded projects. Currently, he leads the **ROBIN project** at Universidad de Córdoba, funded to address societal challenges in Andalusia. His research focuses on protective coatings to improve the long-term stability of sodium-ion battery electrodes, aligning regional needs with European priorities for sustainable and commercially viable energy storage solutions.

SYNATRA Project - Synergistic Architectures for Next Gen Agrivoltaics Incorporating Transparent Organic Solar Modules

Ignasi Burgués-Ceballos^{1*}, Paula Pinyol-Castillo^{1,2,3}, Katerina Nikolaidou², Martí Gibert-Roca², Martín Martín-Ruiz³, Margalida Vidal-Tur⁴, Verónica Tijero⁵, Luis Asín⁵, Jaime F. Martínez-García⁴, and Mariano Campoy-Quiles³

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Abstract:

Conventional silicon-based photovoltaics present limitations when used in agrivoltaic systems, as they compete with crops for sunlight and create uneven shading, which can disrupt consistent plant growth. In contrast, organic photovoltaics (OPVs) show exceptional light absorption tunability, allowing for custom solutions that require high transparency or wavelength selectivity. The SYNATRA project aims at transforming agrivoltaics by incorporating semitransparent OPV modules with tailored light absorption into agricultural protective structures to stimulate a synergistic co-production of energy and plants. We have conducted an extensive screening of organic semiconductor blends to identify the most promising photoactive systems. Our combined investigations on solar cell optimisation and the seedling growth of

model plants under OPV-filtered light has led us to the choice of the ternary blend PTB7-Th:IEICO4F:PC70BM. Subsequently, we have optimised the multistack of the OPV devices and built rigid and flexible modules at lab-scale. Later on, we have built a set of 48 OPV semitransparent modules in an industrial roll-to-roll line, with a total area of 10 m². The study monitors the variations in device performance that result from the upscaling processes to evaluate and mitigate efficiency losses. The 10 m² prototype demonstrator has been installed in an apple orchard experimental station, which represents the first installation of this kind in Spain. We have been monitoring both the photovoltaic production and a series of metrics relevant for plant growth during the fruit growing period. This interdisciplinary study brings together the challenges and opportunities of the simultaneous production of energy and plants, and showcases the huge potential of semitransparent OPV for modern agrivoltaic installations.

Biography:

Ignasi Burgués-Ceballos received his PhD in Chemistry (2014) from the Institute of Materials Science of Barcelona (ICMAB-CSIC). He has alternated postdoc periods at Cyprus University of Technology and at ICFO – The Institute of Photonic Sciences, with senior scientist positions at Merck Group and at Eurecat. He joined UPC in 2024 as a Ramón y Cajal Research Fellow. His main research contributions pivot around nanostructured organic and hybrid semiconductors for energy conversion processes, with a focus on photovoltaics (solar-to-electricity) and photocatalysis (solar-to-fuel).

Chalcogen-Tuned Band-Gap Engineering in Ag(InGa)Zn(Se_yS_{1-y})₂ Quantum Dots Enables Cascade Alignment with TiO₂/ZnS-NiFe LDH for Efficient Photoelectrochemical Water Splitting

Oluwasesan Adegoke*, and Kayode Omotayo Adeniyi

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Abstract:

Photoelectrochemical water splitting requires precise control of band alignment to maximise charge separation and catalytic efficiency. In this work, compositionally tuned Ag(InGa)Zn(Se_yS_{1-y})₂ quantum dots (QDs) with varying Se/S ratios were synthesized to achieve chalcogen-mediated band-gap modulation and integrated into a TiO₂/QDs/ZnS-NiFe layered heterojunction. Increasing Se content raised the valence band maximum and narrowed the band gap, as confirmed by projected density of states analysis, spectroscopy and electrochemistry. The tailored band structure established cascade alignment, enabling efficient downhill electron transfer to TiO₂ and uphill hole extraction through ZnS to NiFe-LDH, which enhanced internal electric fields and interfacial charge dynamics. The heterostructure exhibited broadband absorption and reduced recombination, leading to a photocurrent density of 0.65 mA cm⁻² and a hydrogen evolution rate of 3.5 μmol h⁻¹ cm⁻² under visible light with sacrificial agent. In a two-electrode configuration, overall water splitting was achieved at 1.23 V vs NHE without sacrificial agents, delivering 0.25 mA cm⁻² with excellent stability. This study demonstrates that anion alloying, ZnS passivation and NiFe-LDH catalysis provide a synergistic strategy for constructing cascade-aligned photoanodes for efficient and durable solar-to-hydrogen conversion.

Biography:

Dr. Oluwasesan Adegoke is a Materials Scientist and Chemist and currently a Senior Lecturer (Teaching

and Research) at the School of Science & Engineering, University of Dundee, UK. He is an interdisciplinary researcher whose is skilled in the synthesis of materials and the application of nanotechnology to develop electrochemical and optical sensors/biosensors for the defense and security, food, environmental and biomedical sector. His interest also lies in the application of nanotechnology for renewable energy, specifically photoelectrochemical water splitting for hydrogen evolution. He lectures both in materials and manufacturing engineering and in analytical chemistry.

Organic Photovoltaics for Urban Environments

Sergi Riera-Galindo

Institute of Materials Science of Barcelona (ICMAB-CSIC), 08193 Bellaterra, Spain

Abstract:

Organic photovoltaics (OPV), while offering unique advantages such as flexibility, light weight, and tunable transparency, cannot yet compete under standard 1 sun AM1.5 conditions with conventional silicon solar cells, which currently dominate the market thanks to their higher efficiency, superior long-term stability, and low production costs. Therefore, the future of OPVs lies in identifying niche applications where their intrinsic properties provide a competitive edge. One promising direction is their integration into urban environments, where light intensity and spectra differ significantly from outdoor sunlight, and where flexibility, aesthetics, and lightweight design are valuable. Moreover, the optical coefficients of organic semiconductors allow OPVs to harvest diffuse and off-angle light more efficiently than traditional photovoltaic technologies, providing an additional benefit under the complex illumination conditions typical of cities.

In this work, we demonstrate how controlling the molecular weight of the donor polymer can enhance the morphological stability of OPV active layers, leading to improved device durability under real-world operating conditions (Riera-Galindo *et al.*, *Small*, 2024). Furthermore, we have optimized and characterized ternary blend devices specifically tailored for urban illumination conditions, considering the reduced light intensity and spectral distribution typical of indoor and shaded areas. Our results show that these ternary systems not only improve light absorption and charge transport under low-light conditions but also maintain high stability. Finally, we have fabricated an OPV module achieving a power conversion efficiency of 12.2 %, highlighting the potential of tailored OPV technologies for efficient, durable, and sustainable energy harvesting in urban settings.

Biography:

Dr. Sergi Riera-Galindo has made significant contributions to the field of organic semiconductors, specializing in the performance, scalability, and stability of organic photovoltaic and thermoelectric technologies. He holds a PhD in Electronic Engineering (2015), an MSc in Energy (2013), and a BSc in Industrial Engineering (2009) from Polytechnic University of Catalonia. He has conducted postdoctoral research at ICMAB-CSIC and Linköping University, collaborating with Epishine AB. Between 2022 and 2024, he was an MSCA-IF Fellow, and since 2024, he has been a Tenured Scientist at ICMAB-CSIC.

Nickel-Induced Reduced Graphene Oxide Nanoribbon Formation on Highly Ordered Pyrolytic Graphite for the Hydrogen Evolution Reaction

Gonzalo García*, Alejandro González-Orive, Meylin Sanabria León, Alexander Iguini, and Maximina Luis-Sunga

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Abstract:

The development of nanoribbon-like structures is an effective strategy to harness the potential benefits of graphenic materials due to their excellent electrical properties, advantageous edge sites, rapid electron transport, and large specific area. Herein, parallel and connected magnetic nanostructured nanoribbons are obtained through the synthesis of reduced graphene oxide (rGO) using NiCl_2 and $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}$ as precursors with potential application in the hydrogen evolution reaction (HER).

Several analytical techniques have been used for the thorough characterization of the modified surfaces. Atomic force microscopy (AFM) shows the characteristic topographical features of the nanoribbons. While X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), and Raman spectroscopy provided information on the chemical state of metals and graphene-like structures, magnetic force microscopy (MFM) and scanning Kelvin probe microscopy (SKPFM) confirmed the preferential concentration of metal onto rGO nanoribbons. These results indicate that the synthesized material shows 1D ordering of metal nanoparticles decorating tiny rGO flakes into thin threads and the subsequent 2D arrangement of the latter into parallel ribbons following the topography of the HOPG basal plane.

On the other hand, differential electrochemical mass spectrometry (DEMS) was used to precisely determine the onset potentials and rate-determining steps (RDS) for the HER in acidic media. Remarkably, ionic currents indicate that $\text{Ni}_{0.6}\text{Mo}_{0.4}/\text{rGO}$ catalyst exhibits an onset potential and a RDS for the HER analogous to those developed by Pt-based catalysts.

Biography:

Gonzalo García is an associate professor at the University of La Laguna (ULL, Spain), where he directs the Institute of Materials and Nanotechnology and leads the BIOS research group. He earned a degree in chemistry from the National University of Córdoba (Argentina) and later completed his master's and Ph.D. in chemistry and chemical engineering at ULL. He holds an honorary degree from the University of Education, Lahore (Pakistan), and appears in the Stanford ranking of the world's top 2% most influential scientists (2024 & 2025). His research focuses on materials for energy and environmental applications, with emphasis on electrochemistry, electrocatalysis, and light-driven processes.

Nickel, Cobalt and Ferrocene: Promising Combined Catalysts for Enhanced Oxygen Evolution Reaction

Jose M. Abad*, María Victoria Martínez-Huerta, Jesús Cebollada, Alba Duprat-Alvaro, Raquel Sainz, Marcos Pita, and Antonio L. De Lacey

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Abstract:

The Oxygen Evolution Reaction (OER) remains the primary bottleneck in water splitting and related

technologies due to its slow kinetics. There is a pressing need for the development of low-cost, highly active, and stable electrocatalysts as alternatives to the commonly used but expensive Ir- and Ru-based catalysts. In this presentation will show a straightforward and facile preparation of highly efficient OER electrocatalysts, leveraging the synergistic effects of commercial compounds such as cobalt chloride, nickel, and ferrocene. These catalysts exhibit exceptional performance in alkaline conditions, demonstrating high current densities, low overpotential, and high stability. Notably, the optimized Ni/Ferrocene configuration achieves constant potentials of approximately 1.51 V and 1.65 V with overpotentials of ~ 0.278 V and ~ 0.420 V at current densities of 10 and 100 $\text{mA}\cdot\text{cm}^{-2}$ for durations exceeding 26 and 46 hours, respectively. Similarly, the Co/Ferrocene system delivers high activity and stability, benefiting from a cost-effective and scalable approach. The simple synthesis avoids tedious preparation methods, relying on readily available commercial chemicals with minimal metal usage, paving the way for real-device applications in sustainable energy technologies.

Biography:

Jose María Abad is a senior researcher at Instituto de Catálisis y Petroleoquímica (CSIC, Spain). He holds over 20 years of experience and expertise in (bio)electrocatalysis and in the development of new nanomaterials and their bioconjugation with biomolecules. BSc and PhD in Science (Chemistry) at UAM, his research activity has been focused on new synthetic approaches towards nanomaterials for applications such as biological, medicinal, energy, and many others. He has also been involved in biosensor research and development of point of care diagnostic devices (POC) and more recently in electrocatalysts for water splitting.

Influence of Li and Na Addition on the Stability, Structure and Electrocatalytic Activity of (Mg, Co, Ni, Cu, Zn)O High Entropy Oxide for Oxygen Evolution Reaction

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Abstract:

Multicomponent transition metal (TM) oxides, where entropy is utilized as a handle to stabilise solid solutions, have exhibited remarkable potential as electrocatalysts mainly because of synergistic interactions among the active sites. In this work, we report that incorporating alkali metals into transition metal oxides offers an attractive route toward cost-effective, high-performance electrocatalysts for energy conversion technologies. Here, we unveil the stability-activity relationship in rocksalt high-entropy oxides (HEOs) (FeCoNiCuZnO), (LiFeCoNiCuZnO), and (NaFeCoNiCuZnO), synthesized via the solution combustion method, and evaluated them for the oxygen evolution reaction (OER). The introduction of Li^+ or Na^+ leads to a marked enhancement of the stability of the rocksalt solid solution at lower temperatures. This stabilization arises from increased configurational entropy due to cation-vacancy formation, coupled with oxidation of transition-metal cations, particularly Co and Ni, from +2 to +3. Surface-sensitive analysis reveals the emergence of intermediate-spin Co^{3+} ($t_{2g}^5e_{g1}$) species, which, along with electron deficiency in the transition-metal-oxygen network, tunes the adsorption energetics of O^* and OH^* toward optimal values for OER catalysis. Among the compositions studied, ($\text{Li,Fe,Co,Ni,Cu,ZnO}$) exhibits the best electrocatalytic performance, delivering an overpotential of 322 mV to achieve 10 $\text{mA}\cdot\text{cm}^{-2}$ current density with a Tafel slope of $63 \text{ mV}\cdot\text{dec}^{-1}$, while retaining its activity over

30 h of continuous operation in alkaline electrolyte. The demonstrated OER performance surpasses that of most previously reported rocksalt-based electrocatalysts. The findings open avenues for rational design of next-generation earth-abundant, high-entropy oxides for highly efficient electrocatalysts.

Biography:

Dr. Ahmad earned a Diploma in Production Engineering from Ranchi Polytechnic and obtained a Bachelor's degree in Metallurgical Engineering through the Associate membership examination of the Indian Institute of Metals (AMIIM) in 2002. He graduated from IIT Madras in 2010 with a PhD in Metallurgical and Materials Engineering and has done post-doctoral research at Iowa State University (ISU) and Stanford Synchrotron Radiation Lightsource (SSRL). At IIT(BHU), works on scalable fabrication technologies for solar cells and non-conventional ceramic processing. His research interests include multicomponent oxides for catalysis and energy harvesting.

Low-Carbon Footprint Synthesis of Si Anodes for Li-Ion Batteries from the SiO₂ Shells of Diatom Microalgae

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²*Aragon Nanoscience and Materials Institute (CSIC - University of Zaragoza) and Physics Condensed Matter Department, C. Pedro Cerbuna 12, 50009 Zaragoza, Spain*

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Abstract:

Silicon (Si) is one of the most attractive anode materials for next-generation lithium-ion batteries (LIBs) due to its exceptionally high theoretical capacity. However, the large volume changes it undergoes during lithiation and delithiation lead to mechanical degradation and poor cycling stability. To address this, silicon must be nanostructured—a requirement that is typically met through high-temperature or energy-intensive processes with significant environmental impact. Developing low-carbon, low-energy synthesis routes for nanostructured Si anodes remains a major challenge.

In this work, we demonstrate a sustainable approach for producing nanostructured Si-based anodes by transforming the nanoporous SiO₂ exoskeletons of diatom microalgae into silicon through a molten-salt-assisted magnesiothermic reduction (MS-MgTR) process. Utilizing AlCl₃ as the molten salt, the reduction is carried out at just 200 °C, in contrast to conventional magnesiothermic and carbothermal methods that require 650–1900 °C. Crucially, this reaction follows a shape-preserving pathway, retaining the hierarchical porosity and intricate morphology of the original diatom shells—features essential for accommodating silicon's volume expansion and ensuring mechanical stability during battery cycling.

Systematic optimization of reaction parameters, including reagent ratios, heating profiles, and hold times, led to the formation of porous, crystalline Si structures with high surface area and phase purity. Characterization via XRD, SEM, and gas adsorption confirms the successful retention of nanostructure and porosity.

This strategy enables a scalable, low-energy, and low-carbon synthesis of high-performance Si anodes by integrating renewable biogenic templates with mild molten-salt chemistry. Our work establishes a blueprint for sustainable anode material design, where structural integrity, electrochemical performance, and environmental responsibility are achieved in unison.

Biography:

Maria Valeria Blanco is a Ramón y Cajal Researcher at the Institute of Materials Science of Barcelona (ICMAB), specializing in nanostructured anodes for lithium-ion batteries. She holds a PhD in Engineering Sciences and has worked at ESRF (France), NTNU (Norway), and INMA (Spain).

Her research explores nanostructured silicon and silica materials derived from biogenic sources, aiming to mitigate the environmental footprint of battery technologies. Her work integrates sustainable materials design, electrochemical performance optimization, and in situ characterization, contributing to the development of high-performance anodes that combine scalability, cycling stability, and sustainability.

Strategies to Enhance the Performance of the LNMO Cathode for Generation 3b Li-Ion Batteries

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Abstract:

Generation 3b batteries represent the next step in Li-ion technology. They rely on a high-silicon-content anode with high-voltage or high-capacity cathodes, delivering higher energy density, faster charging, and longer cycle life than state-of-the-art Li-ion batteries. Among the cathode candidates, the high-voltage spinel $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$ (LNMO) is a promising Co-free material that can be processed using aqueous binders and solvents, reducing battery manufacturing cost. This presentation will discuss key aspects of LNMO material, including synthesizing high-capacity spinel-based compositions (Li-rich LNMOs), coating/doping strategies to enhance C-rate and cycle life performance, and electrode processability using aqueous binders. For the best-performing sample delivering a high reversible capacity of 142 mAhg^{-1} at 0.1C, and 76.1 mAhg^{-1} at 5C in half-cell, with a capacity retention of 80 % after 200 cycles at 0.5C in full cell, operando battery experiments were conducted to understand the origin of this enhanced performance. Operando X-Ray Diffraction (XRD) and X-ray Absorption Spectroscopy (XAS) revealed clear changes to the typical reaction mechanism of disordered Fd-3m LNMO involving a solid-solution reaction followed by transformation into a rock-salt phase at a high state of charge.

Acknowledgements: This work was supported by the European Commission-financed project IntelLiGent (HORIZON-CL5-2021-D2-01-02) with project ID number 101069765.

Biography:

Dr. Jordi Jacas Biendicho is a senior researcher at the Catalonia Institute for Energy Research (IREC), leading the battery materials group. He works on functional materials, electrode processing, interface characterization, battery degradation, and in-situ battery characterization, including neutron and synchrotron measurements.

Alternative Polymer Host Matrix for Lithium Metal Polymer Solid-State Batteries

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¹Centre for Cooperative Research on Alternative Energies (CIC energiGUNE), Basque Research and Technology Alliance (BRTA), Alava Technology Park, Albert Einstein 48, 01510 Vitoria-Gasteiz, Spain

²Laboratoire de Réactivité et Chimie des Solides, CNRS UMR 7314, Université de Picardie Jules Verne, 80039 Amiens, France

Abstract:

The transition from fossil fuels to renewable energy necessitates advanced energy storage technologies. Lithium-ion batteries (LIBs) are pivotal in this shift, particularly for grid storage and electric vehicles. However, the limited specific capacity (372 mAh/g) and charging performance of conventional graphite anodes hinder progress. Lithium metal anodes, with a high theoretical capacity of 3865 mAh/g, are a promising alternative for next-generation systems such as Li-S and Li-air batteries. Yet, their combination with liquid electrolytes poses safety risks due to dendrite formation and the flammability of the electrolyte. Solid polymer electrolytes offer a safer solution with better mechanical flexibility, but commonly used PEO-based systems suffer from low ionic conductivity and poor oxidative stability. Poly(esters) such as poly(caprolactone) (PCL) and polycarbonates (e.g., PTMC, PPC) have emerged as promising alternatives to conventional PEO-based polymer electrolytes due to their high lithium-ion transference numbers (≥ 0.5) and improved oxidative stability (~ 4.5 V vs. Li^+/Li^0). However, their direct contact with lithium metal results in chemical degradation, especially under high salt concentrations or in the presence of trace solvents, leading to depolymerization and compromised mechanical properties.

To mitigate the aforementioned limitations, we propose a design strategy in which polar solvating moieties are grafted as pendant side chains onto a chemically robust carbon-carbon (C-C) polymer backbone. Specifically, poly(vinyl alcohol) (PVA), a biodegradable polymer, is employed as the precursor, and undergoes esterification to yield poly(vinyl butyrate) (PVBE). The resulting polymer, in conjunction with lithium bis(trifluoromethanesulfonyl)imide (LiTFSI), is investigated as a solid-state dry polymer electrolyte (SPE) for lithium metal batteries. Comprehensive physicochemical and electrochemical characterization is conducted, emphasizing key performance metrics such as high ionic conductivity, wide electrochemical stability window, elevated lithium-ion transference number, and excellent interfacial compatibility with lithium metal anodes—validated through lithium plating/stripping experiments. Furthermore, the integration of this SPE into lithium metal solid-state battery (SSB) architectures is demonstrated. This approach provides a scalable and chemically tunable platform for the development of next-generation, high-energy-density, and intrinsically safe solid-state lithium metal batteries.

Biography:

Shanmukaraj Devaraj is currently a Senior Researcher/Scientist at CIC Energigune, Spain. He completed his Ph.D. (Physics) with a specialization in Solid State Ionics. He was a CNRS Post-Doctoral fellow at LRCS, UPJV, Amiens, France before joining CIC Energigune in 2013. He was also a visiting scientist at University of Technology Sydney (UTS), and University of Wollongong (UOW), Australia. He has co-authored more than 62 publications with 12 International patents. His current research includes the development of new ester-based polymer matrices, nano-hybrid /hindered-glyme electrolytes, metal

anode protective layers, SEI building additives and sacrificial salts for Li/Na ion and sulfur-based batteries.

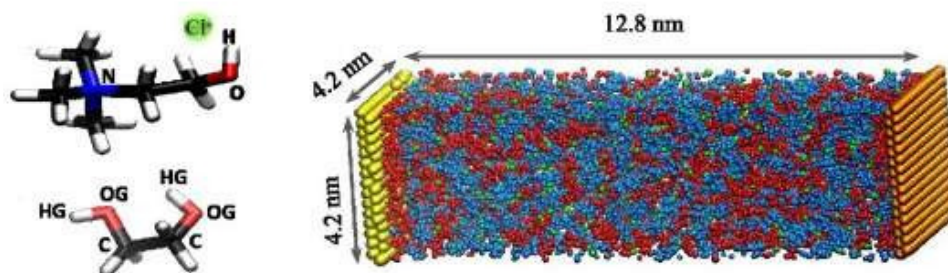
Molecular Dynamics Insights into the Ethaline|Au₍₁₀₀₎ Interface for Sustainable Memory/Storage Applications

M. Natália D.S. Cordeiro*, Iuliia V. Voroshylova, and Elisabete S.C. Ferreira

LAQV-REQUIMTE, Faculty of Sciences/ University of Porto, Porto, Portugal

Abstract:

Technologies leveraging solvent|surface interfaces have an increasing focus on sustainable development. Deep eutectic solvents (DESs) offer a promising avenue to reconcile technological demands with environmental responsibility. In this communication, we move a step forward and present results of extensive molecular dynamics (MD) simulations to probe the interfacial nanostructure arrangements of ethaline DES (choline chloride:ethylene glycol, 1:2 molar ratio) at both neutral and charged monocrystalline Au(100) surfaces across a temperature range spanning from 313 K to 343 K (see figure). Our simulations reveal that at neutral surfaces, the innermost layer comprises all solvent components, with a prevalence of ethylene glycol. While low applied charges maintain this mixed boundary layer despite ionic accumulation, increasing surface polarisation results in distinct innermost layers composed solely of one ionic species and ethylene glycol, forming subsequent counterion-enriched layers. Interestingly, choline cations and ethylene glycol tend to orient parallel to the electrode even at high charges. The camel-shaped differential capacitance curves suggest a complex interplay of electrochemical processes at the DES|Au(100) interface. These detailed molecular insights into the interfacial structure and response of ethaline on gold under varying conditions are crucial for understanding and optimising DES-based electrochemical systems towards sustainable memory and storage applications.



Chemical structure of ethaline and snapshot of the simulation cell along with cell dimensions

Biography:

M Natália DS Cordeiro is a Professor of Computational Chemistry at the Faculty of Sciences, University of Porto (Portugal), heading the Chemistry Material Modelling group at the Associated Laboratory for Green Chemistry (LAQV-REQUIMTE). Her research focuses on computational modelling of functional materials, assessing their properties, reactivity, and safety for applications in electrochemistry, catalysis, desalination, sensing, and energy storage. Employing molecular simulations, quantum-mechanical calculations, and machine learning, she advances the understanding and practical application of

complex materials. Her work builds upon an initial focus on ionic solutions, now expanding to push the boundaries of computational chemistry in materials science.

Green Energy Harvesting from the Air by Capturing CO₂ in an Electrochemical Capacitors

Andrea Lamberti^{1,2*}, Davide Molino¹, Federico Raffone^{1,2}, Pietro Zaccagnini^{1,2}, Alessandro Pedico^{1,3}, Simone Martellone^{1,2}, Giuseppe Ferraro^{1,2}, Sergio Bocchini^{1,2}, Giancarlo Cicero¹, and Candido F. Pirri^{1,2}

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Abstract:

The mixing of two solutions with different compositions leads to the spontaneous release of free energy. This principle, known as salinity gradient power, has been widely investigated for sustainable energy harvesting. Among emerging technologies in this field, Capacitive Mixing (CapMix)—derived from Capacitive Deionization (CDI)—offers a promising route using electrochemical cells akin to supercapacitors. Traditionally applied to liquid systems, CapMix is now being extended to gas-phase gradients, particularly for capturing energy from anthropogenic CO₂. In this work, we propose a novel CapMix approach using an ionic liquid (IL) as both the electrolyte and CO₂-absorbing medium. Specifically, 1,8-Diazabicyclo[5.4.0]undecanium Imidazolid ([DBUH][Im]) is tested in different diluted formulations to tune ionic mobility and CO₂ solubility.

The system operates by alternating a stream of CO₂ and N₂ through a fluidic electrochemical cell equipped with tailored carbon-based gas-diffusion electrodes (GDLs). The presence of CO₂ modifies the electrode/IL interface and the bulk properties of the IL, triggering changes in the electrochemical potential of the cell during charge/discharge cycles. This allows for the conversion of gas-phase mixing energy into electrical energy.

Our results show that energy generation is not governed by electric double layer (EDL) expansion, as in aqueous systems, but by a different mechanism involving shifts in electrochemical potential during CO₂ capture/release. This mechanism is further supported by molecular dynamics simulations.

Additionally, we present optimizations in both electrolyte composition (via dilution strategies) and electrode performance (via increased capacitance of the GDLs). These enhancements lead to voltage variations up to 100 mV and energy/power densities of up to 50 $\mu\text{Wh m}^{-2}$ and 1 mW m^{-2} , respectively.

This work opens new avenues for CO₂-powered electrochemical systems, providing a sustainable path toward energy recovery from emissions.

Acknowledgements: project CO2CAP received funding from the European Research Council (ERC) under the EU's ERC Starting Grant agreement No. 949916

Biography:

Andrea Lamberti is Full Professor of Experimental Physics of Matter at the Politecnico di Torino. He

graduated in Physical Engineering and did a PhD in Electronic Devices in the Italian Institute of Technology. He is the author of over 200 publications and several book chapters and patents in the field of nanomaterials for energy harvesting and storage devices. He has contributed significantly to projects on electrochemical energy devices which have led to numerous European and national projects (MISE, MITE, MASE, Horizon, H2020 and an ERC starting grant).

Nickel@Polypyrrole nanofiber as a High-Performance Electrode Material for Supercapacitor Applications

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Abstract:

Growing demand of energy day by day pushes researchers and scientists to focus on the necessity of green and renewable energy and to store them efficiently in the energy storage devices. Traditional batteries provide high energy density but fall short in power output, while conventional capacitors excel in power but lack energy capacity. Supercapacitors bridge this gap by delivering superior energy storage compared to capacitors and higher power density, fast charge/discharge capability and good cyclic stability than batteries. Efficiency of the supercapacitor mainly depends on the structure and electrochemical properties of the electrode materials and electrolyte. Hence, enhancing the energy densities and cell potential windows of supercapacitors, without compromising their cyclic stability and power density, is critical. The development of efficient and cost-effective electrode materials is critical for advancing supercapacitor technologies. In this study, we report the synthesis and electrochemical evaluation of nickel-doped polypyrrole nanofiber (Ni@PPY NF) as a promising electrode material for supercapacitors. First, PPY NF was synthesized via interfacial polymerization method and then Ni@PPY NF composite was developed by hydrothermal method incorporating nickel ions into the polypyrrole matrix to enhance conductivity, redox activity, and structural stability.

Morphological analysis using SEM revealed a porous, interconnected structure, beneficial for ion transport and charge storage. Electrochemical performance was assessed using cyclic voltammetry (CV), galvanostatic charge–discharge (GCD), and electrochemical impedance spectroscopy (EIS) in a three-electrode configuration with 1 M KOH electrolyte. The Ni@PPY NF electrode demonstrated a high specific capacitance of **1492.7 F/g** at **2 A/g** with excellent rate capability and stable cycling performance. These results indicate that Ni-doping effectively improves the pseudocapacitive behavior of polypyrrole, making Ni@PPY NF a strong candidate for next-generation energy storage devices.

Biography:

Dr. Suparna Das is a Junior Researcher at the CIIAE - Centro Ibérico de Investigación en Almacenamiento Energético in Cáceres, Spain in the department of electrical energy storage. Here, she has been actively involved in the cutting-edge research of the development of materials for energy storage applications. She has a strong background in the synthesis of different types of materials, such as polymers, two-dimensional sheets, composites and inorganic materials and further their application as electrodes or catalysts for different electrochemical applications such as oxygen reduction reaction, methanol oxidation reaction, supercapacitors, batteries and gas sensors.

Development and Investigation of High Surface Area Porous Carbon for Efficient Hydrogen Storage

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Abstract:

Hydrogen, as an energy carrier, possesses unique properties. Being the lightest element, it offers an exceptionally high specific energy — releasing three times more energy upon combustion than gasoline (140 MJ/kg vs. 44 MJ/kg), while producing only water vapor ^[1]. These characteristics make hydrogen an ideal candidate for decarbonizing energy-intensive industries. However, its widespread adoption is currently limited by storage challenges, necessitating further technological breakthroughs to ensure the economic and practical viability of large-scale hydrogen utilization ^[2]. To investigate the hydrogen sorption properties, porous carbon materials were synthesized from biomass derived from rice husk. By varying the synthesis parameters, optimal conditions were identified for producing carbons with a well-developed porous structure. The best-performing sample exhibited a specific surface area of 3721 m²/g, a total pore volume of 2.42 cm³/g, and an average pore diameter of 2.6 nm. Morphological analysis confirmed the presence of a highly developed micro- and mesoporous structure, which positively influences the material's hydrogen adsorption capacity. The hydrogen sorption capacity reached 0.73 wt.% at 298 K and 80 bar, increasing to 9.42 wt.% at 77 K. The obtained results confirm that the developed thermochemical activation method enables the production of carbon materials with a hierarchical porous structure, exhibiting outstanding hydrogen adsorption performance and holding great promise for the development of efficient storage systems.

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Biography:

Dr. Fail Sultanov, Associate Professor, is a Leading Researcher at the PI “National Laboratory Astana”, Nazarbayev University. His research focuses on the synthesis and modification of various carbon-based nanostructured materials, energy storage systems, and the production and storage of hydrogen.

Nanostructured Materials for Energy Conversion

Maria Gimenez-Lopez*, Eugenia Quirós-Diez, and Melanie Guillen

Centro Singular de Investigación en Química Biolóxica e Materiais Moleculares (CiQUS), Universidade de Santiago de Compostela, Spain

Abstract:

Advancing the performance and selectivity of electrocatalysts is critical for both energy conversion and sustainable hydrogen production technologies. In this talk, we present two complementary strategies addressing key challenges in electrochemical devices.

First, we explore the enhancement of oxygen reduction reaction (ORR) selectivity in metal nanoparticles. Using sulfur-functionalized vanadium-based polyoxometalates (POMs) as electrochemically active layers, we modify gold nanoparticles (AuNP@POM) and anchor them onto carbon nanofiber supports. This approach scavenges undesired ORR intermediates, improves oxygen diffusion, and enhances stability against impurities and across a broad pH range. The resulting electrocatalysts demonstrate superior selectivity, activity, and durability compared to conventional Pt/C systems, highlighting the potential of POM-based surface engineering for less selective metal nanoparticles.

Second, we discuss the integration of hydrogen evolution reaction (HER) with urea oxidation (UOR) for energy-efficient hydrogen generation. Sulfur-doped nanostructured supports serve as versatile platforms to stabilize active metal nanoparticles, improving activity and long-term stability for both reactions. These materials enable reduced overpotentials, faster kinetics, and efficient hydrogen production in a two-electrode electrolysis setup, outperforming conventional water-splitting systems. Importantly, this strategy offers a sustainable route to valorize urea-rich wastewater while addressing the limitations of slow UOR kinetics and high-cost catalysts.

Together, these studies illustrate the power of nanoscale material design and surface functionalization in advancing multifunctional electrocatalysts. By combining tailored metal-support interactions, POM-based surface modification, and sulfur-doped architectures, we demonstrate pathways to improve selectivity, efficiency, and durability in both fuel cell and hydrogen production technologies. This work provides insights into the rational design of next-generation electrochemical materials, offering promising solutions for clean energy conversion and sustainable resource utilization.

Biography:

Dr. Gimenez is Oportunius Research Professor at University of Santiago de Compostela (USC) and group leader on nanomaterials for energy applications at CIQUS. After her PhD at Valencia University, she completed postdoctoral research in Nottingham as a Marie Curie Fellow. She began her independent career as a Royal Society Fellow and later became Assistant Professor at Nottingham and Associate Professor at USC. She has led 18 projects supervised multiple PhD theses, holds four patents, and has a high-impact publication record including Science, Nat. Mater., and Nat. Chem. Her work has earned multiple fellowships and awards, including ERC-StG and POC Grants and the 2012 Emerging Investigator Award from the Spanish RSC.

Comparative Safety Assessment of Commercial Cylindrical 18650 Sodium-Ion Cells and POLiS Reference Pouch Cells

Carlos Ziebert^{1*}, Karsten Geuder¹, Philipp Finster¹, and Ijaz Ul Mohsin¹

Abstract:

The interest in post-lithium batteries as an alternative to lithium-ion batteries boosted recently due to their substantial abundance, low cost, and sustainability. However, safety remains a critical barrier. With seven Accelerating Rate Calorimeters and extremely sensible Tian-Calvet calorimeters, the Battery Calorimeter Laboratory at the IAM-AWP of KIT offers the evaluation of thermodynamic, thermal and safety data for lithium-ion and post-lithium cells on material and cell level. Our holistic approach to ensure a safe upscaling of new battery technologies. In the framework of the highly competitive Excellence Strategy competition of the federation and the federal states of Germany, the POLiS (Post Lithium Storage) Cluster of Excellence was started at KIT and Ulm University in 2019 and recently the second 7-year funding period was granted. In POLiS reference sodium-ion pouch cells have been developed and also first commercial cylindrical sodium-ion cells in different formats are becoming available. Therefore, a comparative safety assessment of commercial 18650 cells and the POLiS reference cell has been performed. Two abuse methods were applied: thermal abuse using the heat-wait-see test and mechanical abuse by nail penetration, both in an accelerating rate calorimeter (ARC). The critical parameters have been determined and compared for both types of cells. In addition, a cyclic ageing study has been performed on the commercial 18650 cells and the influence. This study investigated the influence of operating temperature (0°C, 25°C, and 40°C) and discharge rates (1C, 2C, and 3C) on the cyclic aging and the safety. The results together with post-mortem analysis using scanning electron microscopy reveal significant correlations between operating temperature, discharge rates, and safety parameters such as sodium plating and exothermic reactions, and self-heating rates. Insights from this study provide valuable guidance for optimizing the temperature management strategies of sodium-ion battery systems to enhance their longevity and safety in applications.

Biography:

Dr. Ziebert earned his PhD in Physics from the Saarland University Saarbrücken. In 2002 he joined the KIT, where he is currently the leader of the group “Batteries – Calorimetry and Safety”. Since 2011 his research is focused on electrochemical-thermal and safety characterization of Li-ion cells, where he has been leader in 5 projects. He has 23 years of international R&D experience and has published 104 peer-reviewed articles with a h-index of 26. In the POLiS - Excellence Cluster for Battery Research for Post Lithium Storage he is responsible for the thermal characterization and safety of Na and Mg cells.

Designing Carbonaceous Materials for Environmental Applications

Nieves López Salas

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Abstract:

Doped carbonaceous materials have emerged as promising candidates for advanced electrochemical energy storage and electrocatalysis due to their enhanced conductivity, stability, and catalytic activity. Typically, these materials are tailored by introducing heteroatoms such as nitrogen, sulfur, or phosphorus into the carbon matrix, which alters the local electron density, introduces active sites for different reactions ^[1], acts as binders for metallic active centers ^[2], and prevents oxidation in harsh

electrochemical environments. Understanding the structure-property relationships of these materials is crucial for optimizing their electrochemical and catalytic performance.

Our ongoing research focuses on the controlled synthesis of highly doped carbonaceous materials and the investigation of their interactions in aqueous environments. We have developed various synthetic strategies to prepare highly oxygen- and nitrogen-doped carbon materials using pre-defined molecular carbon precursors^[3,4]. These tailored materials exhibit tunable porosity and chemical functionalities, which significantly impact their performance in electrocatalytic and energy storage applications.

To gain insights into how functionalization affects (electro)catalytic behavior, we employ advanced characterization techniques, including solid-state nuclear magnetic resonance (NMR)^[4], in-situ X-ray photoelectron spectroscopy (XPS), and sorption analysis. These methods allow us to probe the chemical environment, electronic structure, and surface interactions of the doped materials in real-time. Notably, our findings reveal that while the introduction of heteroatoms improves hydrophilicity, water has difficulty accessing small, highly doped pores despite their modified surface chemistry. This unexpected behavior may influence the material's performance in aqueous electrochemical systems and suggests that precise control of pore architecture is essential for optimizing their practical applications.

This work contributes to a deeper understanding of doped carbonaceous materials and provides valuable insights into designing next-generation materials for electrochemical energy storage and catalytic applications.

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- [4] I. Lamata-Bermejo, et al; *Angew. Chem. Int. Ed.*, 2024, 63, e202411493.

Biography:

Jun. Prof. María de las Nieves López Salas works at Paderborn University as Chair of the Sustainable Materials Chemistry division. She is a researcher specializing in carbon-based materials with tailored compositions and pore structures. She holds a Master's and Ph.D. in Electrochemistry, both awarded with honors. She conducted postdoctoral research at the Max Planck Institute of Colloids and Interfaces, leading a research group from 2019-2022. With over a decade of experience, her work focuses on sustainable nanocarbons for energy storage, gas adsorption, and catalysis. Currently, she investigates water-porous carbon interactions.

Mass Transport in Iron, FeCr Alloys and Ferritic Steels

Olga Kulitckaya*, and Vladislav Kulitckii

University of Münster, Münster, NRW, Germany

Abstract:

As coal use declines, industry increasingly adopts low-carbon and hydrogen-based processes, exposing structural metals to hydrogen-rich environments. Hydrogen can profoundly degrade the performance of many materials: it accelerates surface reactions, accumulates at defects and crack tips, and promotes embrittlement, corrosion, and loss of mechanical properties. Overcoming these risks requires a comprehensive understanding of how hydrogen modifies mass transport in widely used Fe-based

materials. Chromium improves the corrosion resistance of iron, while steel microstructures deliver higher strength than pure Fe; however, the effect of atomic (gaseous) hydrogen on mass transport in these systems remains underexplored compared with studies of hydrogen diffusion itself. Beyond permeation and trapping of hydrogen, a central question is whether hydrogen perturbs the native point-defect populations that control Fe self-diffusion and, by extension, mass transport. Here, we address this gap by examining the influence of atomic hydrogen on transport and microstructural evolution in pure iron, FeCr alloy and ferritic steel- materials representative of industrial practice. The comparative design isolates composition and microstructure effects; consequently, changes in transport are attributable to hydrogen-defect interactions rather than to intrinsic alloy chemistry. Mass transport was quantified using radiotracer methods and microstructural changes were investigated. This correlative approach links tracer-derived diffusivities to defect densities and short-range order, providing a mechanistic bridge between atomic-scale processes and microstructural evolution. We find that exposure to atomic hydrogen markedly accelerates self-diffusion in all three materials. The kinetics are consistent with hydrogen-induced vacancy supersaturation and hydrogen-enhanced localized plasticity, which raise the mobile defect density and effectively lower the apparent activation barrier for Fe self-diffusion. The observed enhancement is analyzed across atomic, microscopic, and macroscopic scales, considering trapping and release processes, defect generation, and their coupling to diffusion and corrosion. These results clarify the role of atomic hydrogen in governing mass transport in Fe-based alloys and help explain degradation pathways that lead to reduced mechanical performance and increased failure rates in hydrogen-containing environments.

Biography:

Dr. Olga Kulitckaya is a research scientist at the University of Münster. She is currently supported by a DFG grant to investigate the impact of hydrogen on mass transport in iron and iron–chromium alloys. Dr. Kulitckaya has conducted research funded by the Alexander von Humboldt Foundation, the Marie Skłodowska-Curie Actions, and the DFG. She is a recognized expert in materials science and mass transport. Her research interests focused on metallic materials, ceramics, and minerals.

Young Researchers Presentations

Solid State Electrolytes by Hybridization of Ionomer Membrane: Elaboration and Properties

J. Alchemaly^{1*}, Y. Faria Guimarães Silva¹, C. Coltin², V. Dufaud², C. Santini², J.F. Martin³, S. Martinet³, H. Mendil-Jakani¹, and L.Gonon¹

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²*University of Lyon, CPE Lyon, CNRS, UMR 5128, Catalysis, Polymerization, Processes and Materials (CP2M), 43 Bd du 11 novembre 1918, F69616 Villeurbanne cedex, France* ³*Univ. Grenoble Alpes, CEA, Liten, DEHT, 38000, Grenoble, France*

Abstract:

Energy storage and power batteries with high energy density are in high demand due to the increasing growth of portable consumer electronics and electric vehicles^[1]. Lithium-ion batteries are the technology of choice today for such systems, however they still need further improvements to perfectly meet specific requirements in terms of energy density and safety performance. Currently, liquid electrolytes consisting of lithium salts dissolved in polar organic solvents are used, which have a strong conductivity (~10

mS·cm⁻¹) but can cause system polarization due to anion and cation mobility, and are electrochemically unstable and potentially dangerous^[2]. Consequently, the development of solid electrolytes with high Li⁺ conductivity, electrochemical stability, and minimal anion mobility is of tremendous interest, but remains a difficult task^[3].

The goal is to design a single-ion hybrid electrolyte where the ionic conductivity is de-coupled from the segmental relaxation of the polymer chains in order to reach the most advantageous performance. Our approach will make use of the patented concept of sol-gel hybridization of ionomer membrane to overcome the above-mentioned problems^[4]. The interest lies in using well-known commercial ionomer membranes with a percolated nanostructured morphology as a framework to grow a lithium conducting polysiloxane network, forming efficient solid-state hybrid polymer electrolytes. The highly acid environment within the ionomer facilitates an acid-catalyzed sol-gel condensation. The host membrane will provide the good mechanical properties and the integrity of the structure while the single-ion conduction will mainly be provided by the anions grafted onto the siloxane backbone.

We explore how the synthesis conditions can influence the electrochemical properties by altering the anion chemistry of the sol-gel precursor, membrane pre-swelling conditions, and polysiloxane phase composition (which can be validated by FTIR and mass uptake). This in-depth understanding enables us to optimize sol-gel precursors and synthesis parameters to enhance electrolyte performance and efficiency.

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Biography:

Jean Alchemaly, is currently in the second year of a PhD at CEA Grenoble and Université Grenoble Alpes, working on the topic described in the submitted abstract. He holds two master's degrees—one in Physical Chemistry of Materials and another in Nanochemistry—and has nearly four years of industrial experience in the pharmaceutical sector prior to beginning his doctoral studies. His background integrates academic research with practical industry expertise, shaping a strong interdisciplinary approach to science.

Microstructure Modeling for Efficient Processing

Talina Terrazas^{*1,2}, Annika Hämmerle³, and Maria Cecilia Poletti^{1,2}

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²*Christian Doppler Laboratory for Design of High-Performance Alloys by Thermomechanical Processing, Kopernikusgasse 24/I, 8010 Graz, Austria*

³*Neuman Aluminium Industries, Werkstraße 1, 3182 Marktl, Austria*

Abstract:

Designing thermomechanical processing routes is crucial for enhancing processing efficiency while ensuring control over the resulting mechanical properties. This work proposes a physics-based model

that predicts microstructure evolution during complex thermomechanical treatments. The model describes the evolution of microstructural components such as dislocation densities, boundary misorientation distributions, fractions of grain boundaries, and grain and subgrain sizes during plastic deformation and subsequent heat treatments. We coupled these evolutions during plastic deformation with constitutive equations to predict the material's flow stress as a function of strain, strain rate, and temperature. After deformation, the stored dislocation energy drives dynamic and static restoration during the subsequent heat treatment. To validate the model, we cold-deformed cylindrical samples between 25°C and 150°C and at strain rates between 0.1 s⁻¹ and 1900 s⁻¹. Following deformation, we heated the samples to the solid solution heat treatment (SSHT) temperature at controlled heating rates between 1 K/min and 20 K/min. After the different stages of processing, the microstructures were characterized using scanning electron microscopy assisted by electron backscattered diffraction. We used the experimental flow curves from the compression tests and detailed microstructural analysis of deformed and heat-treated samples to calibrate the model. The model and experiments show, that the material presents a strain rate sensitivity at room temperature due to the formation of dislocation pileups and arrays. After deformation, we determined that the start temperature of recrystallisation increases with increasing heating rate, and is independent of the deformation rate. We also demonstrated the competing role of recovery during restoration. In this sense, our study advances the understanding and description of restoration phenomena in aluminium alloys and unravels trends applicable for custom microstructure design.

Biography:

Talina Terrazas earned her degree in Electromechanical Engineering from Gabriel René Moreno State University, Bolivia. She pursued her Master's in Advanced Materials Science at TU Graz, Austria, specializing in metals and ceramics. Since 2022, she has been a University Assistant and PhD candidate in the Modelling and Simulation Group at the Institute for Materials Science, Joining, and Forming at TU Graz. Her research focuses on modeling microstructural phenomena during the thermomechanical processing of metals, especially aluminum alloys.

Poster Presentations

Covalent Modification of Polymers as a Tool for the Production of New, Bioactive Materials for the Regeneration of Osteochondral Defects

Katarzyna Harażna*, Kamila Lis, Karina Niziołek, Dagmara Słota, Bożena Tyliczszak, and Agnieszka Sobczak-Kupiec

Cracow University of Technology, Faculty of Materials Engineering and Physics, Department of Materials Engineering, Cracow, Poland

Abstract:

Covalent polymer modifications enhance their functionalities by forming chemical bonds with other molecules. These alterations significantly improve the mechanical, thermal, and chemical properties, enabling diverse applications in materials science, nanotechnology, and biomedical engineering. Given the intricate biological processes involved in osteochondral tissue regeneration, these advanced modified polymers present a powerful, tailored solution to markedly enhance osteogenesis and ensure optimal integration of implants with surrounding tissues. Moreover, covalent modifications of polymers can enable to obtain the materials that will support the extended release of bioactive compounds that are crucial for bone and cartilage regeneration. Subsequently, the introduction of new functional groups into the polymer structure enables it to be crosslinked with other macromolecules using both chemical and enzymatic approaches.

This work presents the possibility of obtaining modified polymers, i.e. polysaccharides/polyesters/proteins, and their application in the construction of three-dimensional scaffolds for the regeneration of osteochondral tissue defects. The modified polymers were obtained using reagents such as 1-Ethyl-3-(3-dimethylaminopropyl)carbodiimide (EDAC) and N-Hydroxysuccinimide (NHS) or/and 4-Dimethylaminopyridine (DMAP) and N,N'-Dicyclohexylcarbodiimide (DCC) or/and *p*-Toluenesulphonic acid (*p*-TSA). It has been demonstrated that modified polymers enable the production of scaffolds using techniques such as freeze-drying, enzymatic cross-linking, and solvent casting combined with porogen leaching.

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Biography:

Katarzyna Harażna is postdoctoral researcher working in Department of Materials Engineering at Cracow University of Technology. She conducts interdisciplinary research focusing on use of biopolymers, combining disciplines such as biotechnology, polymer technology, surface chemistry, materials engineering and tissue engineering. Principal investigator researcher, scholarship holder in projects funded by National Science Centre, PL; National Centre for Research and Development, PL; Polish National Agency for Academic Exchange. Laureate of START Scholarship for outstanding young scientists (2024), FEBS Scholarship (2021), Iwanowska Scholarship (2020). She completed research internships at University of Sheffield, Institute of Macromolecular Chemistry, Czech Academy of Sciences; University of Westminster.

3D-Printed Bioactive Composites: Polymer-Ceramic Materials for Bone Repair

Dagmara Słota^{1,*}, Julia Sadlik¹, Edyta Kosińska¹, Karina Niziołek¹, Kamila Lis¹, Mateusz M. Urbaniak², and Marcin Wekwejt³

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²*University of Lodz, Faculty of Biology and Environmental Protection, Department of Immunology and Infectious Biology, 12/16 Banacha St, 90-237 Łódź, Poland*

³*Gdańsk University of Technology, Faculty of Mechanical Engineering and Ship Technology, Biomaterials Technology Department, 80-233 Gdańsk, Poland*

Abstract:

Bioactive ceramic-polymer materials are extensively studied for bone tissue engineering due to their potential to enhance regeneration. Polymers are gaining an advantage over traditional ceramic and metallic materials because of their ease of processing, tunable mechanical properties, and biocompatibility. However, the addition of bioactive ceramics is crucial to ensure properties similar to human bone, promoting faster osteointegration. Ceramics, is widely used in orthopedics and dentistry due to its similarity to natural bone mineral. However, its brittleness limits its standalone applications. To overcome this, combining it with a polymer matrix improves its mechanical performance while maintaining bioactivity.

The goal of this research was to develop an optimized polymer-ceramic composite that accelerates bone regeneration after implantation. Selecting the right ceramic and polymer phases was crucial to achieving optimal biological and mechanical performance. The polymer phase was an inert thermoplastic polymer. The resulting composite material was used to 3D print implant prototypes.

Experimental studies in simulated biological environments have demonstrated that these composite support apatite mineralization, indicating their ability to enhance bone formation. The presence of new layers was confirmed by surface imaging. A change in mechanical parameters due to the addition of ceramics was also observed. The developed material provided an optimal combination of bioactivity, mechanical stability and printability making them promising candidates for next-generation bone implants.

Acknowledgements: The authors gratefully acknowledge the financial support of the project: “Bioactive composite granules with potential for 3D printing LIDER14/0266/2023”.

Biography:

Dagmara Słota, M.Sc. Eng., focuses on the development of bioactive polymer-ceramic composites for biomedical applications, particularly in bone tissue engineering. Her research explores material properties, biocompatibility, and the potential of advanced composites for 3D printing of bone implants. Her work integrates materials engineering, biotechnology, and regenerative medicine, with an emphasis on designing personalized, biofunctional implants. She also has experience in designing carriers for active substances and drugs, including for oncology.

Influence of PEEK Processing Methods on its Physicochemical Properties and its Potential Use as a Biomaterial

Julia Sadlik*, Edyta Kosińska, Karina Piętak, and Dagmara Słota

Department of Materials Science, Faculty of Materials Engineering and Physics, Cracow University of Technology, Krakow, Poland

Abstract:

In the biomedical field, the characterisation and properties of polyetheretherketone (PEEK) and its sulfonated derivative, sulfonated polyetherketone (SPEEK), have attracted considerable attention due to their promising applications in implants and tissue engineering. Polyetheretherketone (PEEK) is a high-performance thermoplastic polymer with excellent mechanical strength, chemical resistance and biocompatibility. It is a promising alternative to traditional implant materials such as titanium and ceramics. Despite its many advantages due to its bioinertness, it is subjected to various modification processes in order to improve its bioactive properties. One of these is the sulphonation process, yielding sulphonated PEEK (SPEEK). This modification introduces sulfonate groups ($-\text{SO}_3\text{H}$), which increase hydrophilicity, ionic conductivity and biocompatibility, making SPEEK a more suitable material for applications in tissue engineering and drug delivery systems. The aim of this study was to analyse the processing of PEEK and the effect of the sulphonation process on the physicochemical properties, and to evaluate the potential benefits of this modification. The study involved the synthesis of SPEEK by treating PEEK with concentrated sulphuric acid and evaluating the changes using a range of analytical methods. To characterise the materials obtained, the methods used were: Infrared spectroscopy (FTIR) to confirm the presence of sulfonic groups and changes in the spectra of the materials, Scanning Electron Microscopy (SEM) to analyse the surface topography with EDS analysis. The results presented suggest that the sulfonic modification of PEEK significantly improves its physicochemical properties, opening up new perspectives for applications. FTIR analysis confirmed changes in the spectra; the surface morphology showed no significant changes. EDS analysis verified the presence of all elemental components.

Acknowledgements: The authors gratefully acknowledge the financial support of the project: “Bioactive composite granules with potential for 3D printing LIDER14/0266/2023”.

Biography:

Julia Sadlik is a PhD student at the Cracow University of Technology, Faculty of Materials Science and Engineering. Her work is centered on biomaterials, with a primary focus on bone tissue and skin. Her research interests include the sintering of titanium alloys and bioprinting.

Calcium Phosphates in Biomedical Applications: Influence of Synthesis Methods on Biological Properties

Karina Niziołek^{1*}, Mateusz M. Urbaniak², Julia Sadlik¹, Edyta Kosińska¹, and Dagmara Słota¹

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²*University of Lodz, Faculty of Biology and Environmental Protection, Department of Immunology and Infectious Biology, 12/16 Banacha St, 90-237 Łódź, Poland*

Abstract:

Calcium phosphate ceramics are a key biomedical material due to their biocompatibility, bioactivity and ability to integrate into bone tissue. In particular, hydroxyapatite (HAp) and other calcium phosphates are widely used in tissue engineering, implantology and as drug carriers. The biological properties of these materials are closely related to their structure, chemical composition and method of synthesis. Among the various techniques for obtaining calcium phosphate ceramics, wet-precipitation methods such as co-precipitation, the sol-gel method or hydrothermal precipitation play an important role. They allow precise control of the chemical composition, morphology and particle size, which directly affects the bioactivity and resorption of the material in a biological environment.

In this study, the relationship between the synthesis method and the biological properties of the obtained calcium phosphates is analysed, which may contribute to optimising their applications in regenerative medicine. Materials were obtained by the wet precipitation method and the metabolic activity of L-929 fibroblasts and hFOB 1.19 osteoblasts in the environment of the materials was evaluated. An assessment of the activation of the NF- κ B pathway by hydroxyapatites was also performed on the THP-1 Blue NF- κ B Cells reporter monocyte model. Based on the study, the materials analysed demonstrated varying cytocompatibility depending on the cell type. The widest range of biocompatible concentrations was observed for L-929 fibroblasts and hFOB 1.19 osteoblasts for selected samples. Additionally, some samples present the ability to activate the NF- κ B pathway at fibroblast- and osteoblast-safe concentrations, which may be important for regulating cellular responses. In future studies, the resulting ceramic materials will provide a reinforcing phase for thermoplastics for 3D printing in regenerative medicine applications.

Acknowledgements: The authors gratefully acknowledge the financial support of the project: “Bioactive composite granules with potential for 3D printing LIDER14/0266/2023”.

Biography:

Karina Niziołek – MSc, PhD student at the Cracow University of Technology in the field of materials engineering. She specializes in polymer-ceramic biomaterials for applications in the regeneration of bone and cartilage tissue. Her research focuses on the development of active substance carriers for regenerative medicine. Author of numerous scientific publications and co-author of patent applications. She has participated in international research projects and conferences, and her work has been awarded at invention exhibitions.

Physicochemical Properties of Calcium Phosphates Obtained by Different Methods

Edyta Kosińska*, Julia Sadlik, Dagmara Słota, and Karina Niziołek

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Abstract:

Nowadays, the number of skeletal-related surgeries is increasing. A particularly difficult case are the facial bones, whose deformation requires an individualized approach. Personalized implants made by 3D printing tailored to the patient's needs make this possible. An essential element is a suitable bioactive and biocompatible material that can be implanted into the body. A good approach may be the

use of ceramic-polymer granules, which will be used to print bone implants. Calcium phosphates, which are a ceramic phase, are one of the best-known groups of biomaterials. Their interest in medicine and implantology is related to its high biocompatibility. It is a natural component of vertebrate bone. On its own as an implant, it is difficult to apply due to its inadequate mechanical properties and brittleness. Combining it with another material can provide excellent application potential.

Calcium phosphates were prepared by using wet precipitation methods. Appropriate synthesis conditions were selected, and the concentrations of the starting substances that translate into Ca/P ratios were determined. To determine the effect of the synthesis conditions on the parameters of the resulting ceramic powders, a series of analyses were carried out. Physicochemical and structural analysis was performed to determine the chemical composition and functional groups in the material, and the Ca/P ratio was determined. Structural parameters such as, morphology or shape and size of the particles were characterized using scanning electron microscopy with compositional analysis (SEM-EDS). Parameters affecting bioactivity and the osteointegration process were also investigated.

The results of the study present different physicochemical properties of calcium phosphates depending on their method of preparation, as well as Ca/P ratios, however, the ceramic powders obtained confirm application potential for medical use in cranial bone defects.

Acknowledgements: The authors gratefully acknowledge the financial support of the project: “Bioactive composite granules with potential for 3D printing LIDER14/0266/2023”.

Biography:

Edyta Kosińska is doctoral student in the discipline: Materials Engineering at the Faculty of Materials Engineering and Physics, Cracow University of Technology. Edyta Kosińska is involved in the broad subject of biomaterials. Edyta Kosińska concerned with materials for bone tissue regeneration, as well as materials for skin applications. Edyta Kosińska is a co-researcher in international projects whose work focuses on the design of implants based on titanium alloy modified with bioactive ceramics for biomedical applications.

Nano-Composite Scaffolds for Osteochondral Tissue Regeneration

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Abstract:

In recent years, tissue engineering has been an interesting alternative for treating osteochondral tissue disorders. Native osteochondral tissue is a combination of two tissues that have different chemical composition, structure and mechanical properties. The differences between cartilage, which is non-vascularised and non-mineralised, and vascularised and mineralised bone present a considerable challenge in developing a suitable osteochondral scaffold ^[1]. The ideal scaffold for regeneration of this tissue should form the so-called interface between bone and cartilage, should simultaneously restore cartilage loss, indirectly calcified cartilage and bone tissue. Gradient scaffolds used for this purpose,

which are able to mimic the hierarchical structure, show effective treatment of bone-cartilage tissue defects [2]. The porous structure of the scaffold contributes to better cell adhesion, proliferation and differentiation. The use of surface modification of polymers makes it possible to change the properties of native components, which states a wider potential for their use while the addition of active substances with anti-inflammatory, antimicrobial and antimicrobial properties can contribute to proper regeneration at the site of application.

This study proposes methods for obtaining gradient scaffolds based on calcium phosphates and polyesters with potential application in the regeneration of osteochondral tissue defects. The materials were subjected to detailed tests to confirm the therapeutic effect.

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Acknowledgements:

Project “Hierarchical approaches for osteochondral tissue engineering”. This research was funded in whole by National Science Centre, Poland, grant no. UMO-2022/45/B/ST8/02557.

Biography:

Dominika Träger is an engineering student specializing in materials for biomedical applications, with research interests in polymers, composites, and hydrogels for drug delivery and tissue engineering. She is the author and co-author of several research and review papers on biomaterials in medicine. Her work has earned recognition through awards for inventions presented at international exhibitions, as well as prizes and research scholarships at the Cracow University of Technology. She is also a recipient of the Minister of Science scholarship.

Innovative Polymer-Ceramic Composites for Functional Osteochondral Tissue Reconstruction

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Abstract:

The regeneration of osteochondral defects poses a significant challenge due to the distinct mechanical and structural properties of cartilage, the subchondral layer, and bone. Developing biomaterials capable of supporting the reconstruction of these complex tissues requires ensuring their biocompatibility, bioactivity, and appropriate mechanical characteristics. Tissue engineering offers innovative approaches to creating scaffolds that promote osteochondral repair. These materials, manufactured using advanced material engineering techniques or chemical/enzymatic synthesis, should exhibit high porosity, osteoconductivity, and adequate mechanical strength to facilitate the regeneration of native tissue.

In addition to their regenerative potential, scaffolds designed for osteochondral applications should possess antimicrobial properties and modulate inflammation at the implantation site. This can be achieved by incorporating bioactive polymers such as chitosan, known for its bacteriostatic effects, or

chemically and surface-modified macromolecules to enhance performance. Furthermore, the ability of these materials to support cellular adhesion and proliferation plays a crucial role in accelerating tissue regeneration. Optimizing the composition and structure of the scaffold is essential to achieve mechanical stability while maintaining a favorable environment for cellular activity. Additionally, tailoring the degradation rate of the scaffold to match the tissue healing process is crucial for ensuring proper integration with host tissue. To further enhance functionality, bioactive factors or growth-promoting agents can be incorporated to stimulate cellular differentiation and extracellular matrix formation.

This study focuses on evaluating the physicochemical, structural, morphological, and mechanical properties of polymer-ceramic composites composed of calcium phosphates and modified polysaccharides (PS-mod). The obtained results confirm the potential of these materials for osteochondral tissue regeneration, highlighting the need for further biological assessment to determine their clinical applicability.

Acknowledgements: Project “Hierarchical approaches for osteochondral tissue engineering”. This research was funded in whole by National Science Centre, Poland, grant no. UMO-2022/45/B/ST8/02557.

Biography:

Bożena Tylińczak, Prof. specializes in biomaterials, advanced drug delivery systems, and functional materials. Her research focuses on the development of innovative materials for regenerative medicine, particularly in bone and cartilage tissue engineering. She explores the physicochemical properties, biocompatibility, and application potential of novel materials in biomedical fields. Her work integrates materials engineering, biotechnology, and pharmacy, with an emphasis on biofunctional implants and controlled drug release. She also has extensive experience in technology transfer, patent development, and expert evaluations for national and international research institutions.

3D-Printed, Biologically Active Layered Scaffolds for Osteochondral Tissue Regeneration

Agnieszka Sobczak-Kupiec*, Katarzyna Harażna, Karina Niziołek, Dagmara Słota, Kamila Lis, and Bożena Tylińczak

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Abstract:

The regeneration of osteochondral tissue defects, which include cartilage and underlying bone, demands scaffolds with specific mechanical and biochemical properties. The strong interplay between these two tissue types highlights the necessity for advanced manufacturing techniques for producing those materials, such as 3D printing. One of the most significant advantages of 3D printing in scaffold fabrication is its ability to achieve precise control over porosity and architecture. These critical features enhance cell migration, nutrient diffusion, and metabolic products removal, ensuring optimal tissue growth and integration during the regeneration process ^[1].

The integration of composite materials in 3D printing has significantly advanced hybrid scaffolds, optimally combining various materials for osteochondral applications. For instance, scaffolds that combine hydrogels with ceramics such as hydroxyapatite demonstrate remarkable bioactivity and improve cellular adhesion and growth, while also offering the mechanical strength required to align with

natural bone tissue. Moreover, advanced manufacturing techniques such as fused deposition modeling (FDM) and multi-material printing allow for the customization of scaffold properties such as porosity, stiffness, and biodegradation rates, enabling tailored solutions that meet specific medical needs and propel tissue engineering forward. Moreover, the inherent adaptability of 3D printing technology permits the incorporation of bioactive materials and growth factors directly into scaffolds. This integration has the potential to significantly enhance chondrogenesis and osteogenesis, both of which are vital processes for effective osteochondral regeneration ^[2].

Herein, the structural, morphological, and physicochemical characterisation of 3D printed scaffolds made of polymers, i.e. ceramics, polyesters, and polysaccharides, which have been functionalised with bioactive compounds, e.g. proteins, will be presented.

Acknowledgements: Project “Hierarchical approaches for osteochondral tissue engineering”. This research was funded in whole by National Science Centre, Poland, grant no. UMO-2022/45/B/ST8/02557.

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Biography:

Professor Agnieszka Sobczak-Kupiec is Vice-Dean in Faculty of Materials Engineering and Physics at Cracow University of Technology. Her research focuses mainly on design, synthesis and characterisation of ceramic and composite materials for osteochondral regeneration. Member of Scientific Policy Committee and Council for Innovation in Science and Higher Education, Poland. She has completed scientific/industrial internships at i.e. University of California Berkeley, University of Strathclyde, and French National Institute for Nuclear Science and Technology. She has been/is principal investigator/researcher in several projects, including those funded by National Science Centre, PL; National Centre for Research and Development, PL; and Foundation for Polish Science.

Multi-Aspect Cathode Porosity Shaping to Increase the Efficiency of High-Temperature Fuel Cells

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Abstract:

In a high-temperature carbonate fuel cell (MCFC), the slowest reactions determining the system's efficiency occur on the cathode surface. Therefore, optimizing this electrode is crucial for increasing the efficiency of the fuel cell. Optimization of the positive electrode can be carried out by two approaches - chemical composition and microstructure. The cathode is formed by tape casting from a slurry with a polymer base where the base material is nickel. The porous structure of the cathode makes carbonate ions CO_3^{2-} and gases (carbon dioxide and oxygen) easily move in the cell. According to the conducted research, the addition of porogens to the slurry, i.e., substances burned during the thermal process and leaving empty spaces in the cathode structure, changes the specific surface area, pore tortuosity, and other parameters, and as a result, increases the fuel cell power density. For example, using porogens with a bimodal particle size distribution doubles this value. Thanks to capillary forces, smaller pores are filled with molten electrolyte and larger ones with reaction gases, intensifying cathodic reactions

(Wejrzanowski, 2017). Since the volume fraction and size distribution of the porogens particles in the cathode had such a dramatic impact on the change in the efficiency of the entire cell, optimizing other pore parameters will also allow for the improvement of the whole device. This research investigates the influence of the shape and the volume fraction of the porogens particles used to form the cathode microstructure on the material properties and, as a result, on the performance of the molten carbonate fuel cell.

Acknowledgements: The research was founded by the National Science Centre, Poland (grant number 2024/53/N/ST11/04353).

Biography:

Gabriela Komorowska graduated in materials engineering (2020). She is a PhD student at the Faculty of Materials Science and Engineering of Warsaw University of Technology in Poland. Her research covers the area of high-temperature fuel cells. Her interests include fuel cells, ceramics, and manufacturing methods of porous materials.

Antimicrobial and Cytotoxic Evaluation of Carvone Encapsulated in Chitosan Particles

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Abstract:

Essential oils (EO) are natural compounds with proven antimicrobial effects against a wide range of microorganisms, including bacteria and fungi. However, they are characterized by low stability, high volatility, and poor solubility in polar solvents. Encapsulation of these compounds into a appropriate carrier may not only improve their stability but also facilitate manipulation and, enhance their bioavailability, which could lead to improved efficacy. Moreover, encapsulation could offer an suitable alternative to synthetic biocides.

The aim of this study was to determinate the antimicrobial and cytotoxic activity of pure and encapsulated carvone in chitosan particles. Samples were tested against bacteria and fungi commonly found on building surfaces. The minimum inhibitory concentration (MIC) was determined using the broth microdilution method. Cytotoxic activity was evaluated after 24 h, 48 h, and 72 h using a cell viability assay on human skin and lung cell lines, with results expressed as inhibitory concentration (IC₅₀).

Pure carvone exhibited relatively low antimicrobial activity, with MIC values ranging from 32 to 2048 µg/mL, whereas the encapsulated form showed MIC values between 512 and 4096 µg/mL, with a theoretical carvone content of 85–682 µg/mL. Chitosan particles alone showed no antimicrobial activity, even resulted in higher microbial growth compared to the growth control in some cases, probably due to the ability of some microorganisms to metabolize chitosan. Based on the evaluation criteria, encapsulated carvone was non-cytotoxic (IC₅₀ > 501 µg/mL), whereas pure carvone was weakly cytotoxic (IC₅₀ = 201 – 500 µg/mL). In addition, skin cells were generally more sensitive compared to lung cells.

Further research will be necessary to characterize prepared chitosan particles and evaluate encapsulation efficiency. However, carvone in combination with chitosan does not appear to be a suitable alternative to biocides; therefore, future research will also focus on other essential oils.

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Acknowledgements:

The research was supported by the Czech Science Foundation (GAČR), grant. no. 24-10395S, Essential oils as new biocides in construction coatings.

Biography:

Tomáš Skala is completing his Ph.D. in Nutrition and Food at the Czech University of Life Sciences in Prague, Department of Food Science. His research focuses on combining cannabis and other plant extracts, as well as essential oils, with nanomaterials. He studies the antimicrobial and antifungal activity of these formulations against skin pathogens and common fungi, along with their cytotoxic and wound-healing effects on human cell lines. His previous academic work, including bachelor's and master's theses, also centered on cannabis and its extracts.

***In Vitro* Antimicrobial and Cytotoxic Activity of Encapsulated Cinnamon Essential Oil in Chitosan Nanoparticles**

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Abstract:

Encapsulation is a technique used to fix an active compound into a carrier material to improve their stability and ideally prolong and improve their effect, which can even lead to higher efficiency. In this work, cinnamon essential oil was encapsulated into chitosan-based nanoparticles. Essential oils are promising natural compounds, known for their antimicrobial activity, with high potential as ecological alternative to synthetic compounds. Their only disadvantage is their low stability and high volatility. The aim of this work was to evaluate if free or encapsulated cinnamon oil could serve as a novel non cytotoxic biocide to building coating. Samples were tested against 12 microorganisms commonly occurring on building surfaces, also their cytotoxicity was evaluated. The determination of minimum inhibitory concentrations (MIC) was performed by broth microdilution method. Cytotoxicity was tested by cell viability assay on human skin and lung cell lines, with results expressed as values of IC₅₀. The encapsulated sample MIC values were in the range from 512 to 4096 mg/L, with the theoretical content of essential oils between 85 to 682 mg/L. Pure cinnamon oil MIC ranged from 64 to 512 mg/L. Interestingly, the combination of cinnamon oil and chitosan in some cases supported the growth of microorganisms. This could indicate probiotic effect of chitosan particles to selected strains. Cytotoxicity tests showed that the encapsulated sample was non cytotoxic, based on criteria that IC₅₀ ≥ 501 mg/L. Pure cinnamon oil ranged IC₅₀ values between moderately cytotoxic (21-200 mg/L) to weakly cytotoxic (201-500 mg/L). However, skin cells were a little bit more sensitive than lung cells based on the

IC₅₀ values. For future studies, it will be important to determine the encapsulation efficiency to ensure the content of encapsulated EOs in the samples. Based on our results, encapsulated cinnamon oil in chitosan does not seem to be an alternative to conventional biocides, for that reason more essential oils and carriers should be subjected to future research.

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Acknowledgements:

The research was supported by the Czech Science Foundation (GAČR), grant. no. 24-10395S, Essential oils as new biocides in construction coatings.

Biography:

Jan Hájíček is a Ph.D. student at the Department of Food Science, Czech University of Life Sciences in Prague, specializing in Food Quality and Agricultural Product Processing. His current research focuses on the application of essential oils in materials for the construction industry, particularly their use in paints to prevent microbial growth on building surfaces. He explores the incorporation of encapsulated essential oils as a sustainable alternative to synthetic compounds. His earlier academic work, including his bachelor's and master's studies, centered on coffee adulteration.

Optimization of Glass Capillary Geometries for Maximum Gravimetric Hydrogen Storage Efficiency

Ramon Muhamed Redzep Beck

Technische Universität Berlin, Berlin, Germany

Abstract:

Hydrogen storage in glass capillaries is recognized as a promising approach for achieving high gravimetric energy density in compact formats. In this study, the geometry of silica-based capillaries is theoretically optimized to maximize storage efficiency under internal pressure constraints. Analytical expressions are derived to relate capillary dimensions to the maximum pressure, limited by the intrinsic tensile strength of the glass. A parametric evaluation is performed to identify diameter-to-wall-thickness ratios that yield the highest hydrogen mass relative to structural mass. Theoretical upper bounds for gravimetric storage efficiency are established and used to guide the design of microstructured capillary systems. These results provide a materials-based framework for improving hydrogen containment strategies in lightweight, high-pressure storage applications.

Biography:

Ramon Beck is a research associate at the Department of Aircraft Design and Lightweight Structures at TU Berlin. His academic background is in Aerospace Engineering, also from TU Berlin, where he has been actively involved in teaching since his undergraduate studies. His research focuses on fiber-reinforced composites, structural hydrogen storage, and numerical simulation. As part of a ZIM-funded project, he investigated continuous fiber-reinforced 3D printing and is currently pursuing a PhD on optimizing glass capillaries for hydrogen storage. His work bridges practical experimentation with scientific rigor to advance innovation in lightweight design.

Photo-Assisted Energy Harvesters and Sensors Using PVDF Matrix Stabilized α -FAPbI₃ Perovskite

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Abstract:

Recent advancements in energy harvesting technologies have led to the development of systems that efficiently convert mechanical energy into electrical power, offering sustainable solutions for a wide range of applications. In particular, piezoelectric materials are paving the way for high-performance, flexible devices capable of energy conversion, storage, and sensing, addressing the growing demand for self-powered and eco-friendly systems. In this study, we present a simple approach to stabilize α -FAPbI₃ by incorporating it into a PVDF matrix, resulting in a stable composite film. Optimized FPC 3 composite containing 300 μ l of α -FAPbI₃/g in PVDF achieved a high electroactive β -fraction ($\sim 96\%$). A comparative study demonstrated that the black phase (α -FAPbI₃) outperformed the yellow phase (δ -FAPbI₃) due to superior interfacial interactions. The optimized device, FPNG 3, generated a peak-to-peak output voltage of ~ 148.4 V and a maximum power density of ~ 81.72 μ W/cm². Additionally, the device exhibited high pressure sensitivity (~ 1.036 kPa/V at 10 Hz frequency and moderate pressure range) with the ability to sense various biomechanical movements. The light-assisted nanogenerator device displayed output variations under no light, white light, and UV light exposure, making it suitable for photo-assisted energy harvesting. A $\sim 63.5\%$ increase in output voltage was observed from the photo-assisted energy harvesting device under white light. Overall, this research highlights the multifunctionality of the FAPbI₃-PVDF composite in energy conversion, storage, and sensing, along with an effective method for stabilizing the metastable, photo-active α -FAPbI₃.

Biography:

Niloy Mridha, pursuing a Ph.D. at the Indian Institute of Technology (IIT) Bombay after completing his B.Tech and M.Tech in Polymer Science and Technology from the University of Calcutta. His research focuses on advanced functional materials, particularly polymer-perovskite composites, hydrogels, and biopolymers, for energy harvesting and sensing applications. He works on developing sustainable, flexible, and biocompatible materials for piezoelectric and triboelectric nanogenerators, wearable sensors, and biomedical devices. With expertise in material characterization and device fabrication, his work aims to bridge materials science with real-world technological innovations in flexible electronics.

Solid State Electrolytes by Hybridization of Ionomer Membrane: Structure-Properties Interplay

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Abstract:

Energy storage and power batteries with high energy density are in high demand due to the increasing growth of portable consumer electronics and electric vehicles^[1]. Lithium-ion batteries are the technology of choice today for such systems, however they still need further improvements to perfectly meet specific requirements in terms of energy density and safety performance. Currently, liquid electrolytes consisting of lithium salts dissolved in polar organic solvents are used, which have a strong conductivity ($\sim 10 \text{ mS}\cdot\text{cm}^{-1}$) but can cause system polarization due to anion and cation mobility, and are electrochemically unstable and potentially dangerous^[2]. Consequently, the development of solid electrolytes with high Li^+ conductivity, electrochemical stability, and minimal anion mobility is of tremendous interest, but remains a difficult task^[3].

The goal is to design a single-ion hybrid electrolyte where the ionic conductivity is de-coupled from the segmental relaxation of the polymer chains in order to reach the most advantageous performance. Our approach will make use of the patented concept of sol-gel hybridization of ionomer membrane to overcome the above-mentioned problems^[4]. The interest lies in using well-known commercial ionomer membranes with a percolated nanostructured morphology as a framework to grow a lithium conducting polysiloxane network, forming efficient solid-state hybrid polymer electrolytes. The highly acid environment within the ionomer facilitates an acid-catalyzed sol-gel condensation. The host membrane will provide the good mechanical properties and the integrity of the structure while the single-ion conduction will mainly be provided by the anions grafted onto the siloxane backbone.

To investigate the morphology of the hybrid electrolytes and its relationship to synthesis conditions and ionic conductivity, we employed a multiscale structural approach covering a broad observation range. This was accomplished by combining advanced microscopy with radiation scattering techniques, taking advantage of the complementary contrasts offered by X-rays and neutrons. The insights gained enable us to fine-tune sol-gel precursors and processing parameters to boost electrolyte performance.

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- [2] Xu et al., 2004, Chem Rev 104, 4303–4417.
- [3] Goodenough et al., 2010, Chemistry of Materials vol.22 587-603.
- [4] L. Gonon, et al., French patented n°1352070, Application date: 7 march 2013.

Biography:

Yan Faria, currently a second-year PhD student at CEA Grenoble and Université Grenoble Alpes. Holds a Bachelor's degree in Materials Engineering from UFSCar and a Master's from Polytech Grenoble in the same field. Academic background combines experimental work in rheology and 3D printing with a current focus on the structural and electrochemical characterization of solid polymer electrolytes, reflecting an interdisciplinary approach to materials science.

Tailoring Electronic Properties of 3D Pt-doped Hydrogenated TiO_2 Nanotube Arrays for Enhancing Hydrogen Evolution in Acidic Media

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Abstract:

Enhancing catalytic activity of hydrogen evolution reaction (HER) during acidic water splitting process while maintaining long-term stability remains a central challenge in the development of advanced electrocatalysts for sustainable green hydrogen production. While platinum (Pt)-based materials is considered as the benchmark for the HER in acidic media, their high cost and scarcity demand strategies to reduce Pt loading without compromising catalytic performance. Hydrogenated titanium dioxide nanotube arrays (H-TiO₂ NTAs) emerge as a promising support due to their excellent chemical stability, high surface area, and enhanced electrical conductivity arising from oxygen vacancies and Ti³⁺ species. In this work, Pt is incorporated into H-TiO₂ nanotube arrays to construct a hybrid catalyst that leverages the synergy between atomically dispersed Pt active sites and the conductive, acid-resistant H-TiO₂ framework. The optimized Pt-doped H-TiO₂ NTAs catalyst exhibits excellent HER performance in acidic media, delivering an overpotential of only 38 mV at 10 mA cm⁻² and the measured Tafel slope suggests that the HER follows a Tafel–Heyrovsky mechanism, with the Heyrovsky step as the rate-determining step. Long-term proton exchange membrane (PEM) electrolysis confirms the catalyst's remarkable stability, sustaining 500 mA cm⁻² for over 400 hours with negligible performance degradation. This synergistic design enables efficient charge transfer, optimized hydrogen adsorption, and improved durability in acidic environments, offering a promising platform for low-Pt HER catalysis.

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Biography:

Hoang Tuan Nguyen is currently pursuing Ph.D. program at Department of Nano Convergence Engineering, Jeonbuk National University (Korea). His research focuses on the design and development of advanced nanomaterials for electrochemical energy conversion applications.

3D Hierarchical Electrocatalyst Derived from Pt,Mo-Dually Doped NiSeO₄/NiSe₂-Coated Co₂P Enables High-Performance Overall Water Splitting

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Abstract:

The development of cost-effective, durable, and high-performance electrocatalysts for overall water splitting (OWS) is essential to advancing green hydrogen technologies. Herein, we report the rational design and synthesis of a highly efficient bifunctional electrocatalyst composed of Pt,Mo-dually doped NiSeO₄/NiSe₂ heterostructures supported on cobalt phosphide (Co₂P) nano substrate, which demonstrates remarkable catalytic activity and long-term operational stability of the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) in alkaline media. The strategic integration of Pt and Mo into the NiSe-based matrix significantly modulates the electronic structure, optimizing the adsorption energies of key intermediates, thus resulting in an ultra-low overpotentials of only 24 mV for HER and 242 mV for OER at a current density of 10 mA cm⁻² in 1.0 M KOH. When assembled the catalyst

as anode and cathode electrodes into a full cell of anion exchange membrane (AEM) water electrolyzer, the developed device obtains an excellent performance under industrial-level current densities with low cell voltage and exciting durability, sustaining 1 A cm^{-2} for over 500 hours with negligible degradation. This study presents a promising strategy for designing advanced electrocatalysts by combining dual-metal doping and heterostructure engineering strategies toward scalable, efficient hydrogen production via alkaline AEM water electrolysis.

Acknowledgements: This research received support from the Basic Science Research Program (2022R1A2C2010339) and the Regional Leading Research Center Program (2019R1A5A8080326) through the National Research Foundation funded by the Ministry of Science and ICT of the Republic of Korea.

Biography:

Thokchom Anjali Devi is a Ph.D. scholar in the Department of Nano Convergence Engineering, Jeonbuk National University. Her current research area focuses on the development of advanced electrocatalysts for sustainable energy applications, particularly in water splitting and related electrochemical processes. She is dedicated to developing innovative, earth-abundant materials to address the global demand for sustainable and clean energy applications.

Rational Design of High Entropy Alloy Nanoparticles-Immobilized Graphene with Rich Exposed Multiple Active Sites for Promoting Water Splitting Kinetics

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Abstract:

The development of high-efficiency, cost-effective electrocatalyst is seriously required for overall water splitting technology to produce green hydrogen energy. Nowadays, although Pt/Ru-based materials are benchmark catalysts highly potential for promoting the kinetics of hydrogen evolution reaction (HER) and oxygen evolution reaction (OER), their expensiveness and insufficient stability for long-term operation in harsh electrolyte conditions seriously limited their wide use in industry. High-entropy alloys (HEAs) are a new class of metallic alloy materials based on solid solutions of five or more elements in equi-/near-equiatomic proportions. In addition to their remarkable mechanical strength, exceptional corrosion resistance, and superior thermal stability promising for various applications, HEAs-based materials have recently been emerging as an innovative category of advanced catalysts, paving the way for a novel field of electrochemical energy conversion studies. In this study, we rationally design a high-performance catalyst derived from NiCoAlFeLaPt HEAs nanoparticles-immobilized reduced graphene oxide sheets (NiCoAlFeLaPt@rGO), which owns unique structure and physicochemical properties with excellent conductivity, large electroactive surface area, and multiple active sites. The catalyst achieves a small overpotential of 33 mV and 279 mV for HER and OER, respectively, at 10 mA cm^{-2} in 1.0 M KOH solution. The alkaline exchange membrane water electrolysis based on NiCoAlFeLaPt@rGO as a bifunctional catalyst delivers a current density of 0.5 A cm^{-2} and 1 A cm^{-2} at 1.73V and 1.84 V, respectively. In addition, the device could operate stably at an industrial-level current density of 1 A cm^{-2} for 1000 hours. The

results evidence high potential of NiCoAlFeLaPt@rGO for green hydrogen production via water splitting applications.

Acknowledgements: This research received support from the Basic Science Research Program (RS-2024-00349472), BRL (RS-2023-00207836), and the Regional Leading Research Center Program (2019R1A5A8080326) through the National Research Foundation funded by the Ministry of Science and ICT of the Republic of Korea.

Biography:

Nguyen Tram Anh Duong is a PhD student at the Department of Nano Convergence Engineering, Jeonbuk National University. Her current research area focuses on the design of advanced nanomaterials for electrochemical energy conversion applications, such as water splitting, metal-air batteries.

Rational Design of CoNi-PtCoNi Dual-Alloy Catalyst for pH-Universal Outstanding Hydrogen Evolution

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²*Center for Carbon Composite Materials & Dept. of Polymer and Nano Science and Technology, Jeonbuk National University, Jeonju, Jeonbuk 54896, Republic of Korea*

Abstract:

Reducing the reliance on platinum group metal (PGM) catalysts for the hydrogen evolution reaction (HER) is crucial for advancing practical proton exchange membrane (PEM) and anion exchange membrane (AEM) water electrolysis. PGM single-atom catalysts (SACs) have emerged as a promising approach by maximizing atomic utilization, but their limited active sites, stability, and tunability of electronic structure constrain performance. Alloying PGMs with earth-abundant transition metals offers an effective strategy to reduce PGM usage while enhancing activity and stability through electronic structure modulation and synergistic interactions. Herein, we report a dual-alloy catalyst comprising CoNi and Pt₃Co_{0.5}Ni_{0.5} alloy sites embedded within a carbon nanotube matrix. This design achieves outstanding HER activity in both acidic and alkaline media, delivering overpotentials as low as 14 and 17 mV, respectively, at 10 mA cm⁻². In full-cell electrolyzer tests, the catalyst operates stably at 500 mA cm⁻² for 500 hours with minimal degradation in both PEM and AEM systems. Experimental and theoretical studies reveal that CoNi promotes water dissociation by modulating interfacial water structures, while Pt-CoNi alloying optimizes hydrogen adsorption free energy, accelerating the Heyrovsky step. The synergistic interaction between CoNi and Pt₃Co_{0.5}Ni_{0.5} provides an effective balance between adsorption and reaction kinetics, offering a robust platform for pH-universal HER catalysis and scalable hydrogen production.

Acknowledgements: This research received support from the Basic Science Research Program (RS-2024-00349472), BRL (RS-2023-00207836), and the Regional Leading Research Center Program (2019R1A5A8080326) through the National Research Foundation funded by the Ministry of Science and ICT of the Republic of Korea.

Biography:

Duy Thanh Tran is working as an associate professor at the Department of Nano Convergence Engineering, Jeonbuk National University. His current research area focuses on the design of advanced

nanomaterials for electrochemical energy conversion applications. He has published about 140 scientific articles, which have been cited 7000 times with h-index of 51 and i10-index of 102.

Lattice Restructuring in Transitional Metal Hexacyanoferrate Positrodes for High Performance Sodium Ion Pouch Batteries

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Abstract:

This study systematically investigates how precursor mixing kinetics influence nucleation-driven lattice modulation in both pristine and dehydrated transition metal-based hexacyanoferrates, using sodium nickel hexacyanoferrate (Ni-HCF) as a model positrode for sodium-ion batteries. By varying the addition sequence of nickel and ferrocyanide precursors, three distinct monoclinic Ni-HCF structures were synthesized. simultaneous mixing (Ni-HCF (BA)), ferrocyanide-limited, and nickel-limited protocols. Among them, Ni-HCF (BA) exhibited the highest sodium content (1.42 Na per formula unit), lowest cyanide vacancy ($\Gamma = 0.15$), and superior crystallinity. Post-dehydration analyses via XPS and XANES revealed the presence of Ni^{3+} species, indicating local lattice distortions induced by water removal, while preserving the overall framework. Electrochemical testing in half pouch cell showed that Ni-HCF (BA) delivered the best performance, achieving a capacity of $73.74 \text{ mAh}\cdot\text{g}^{-1}$, minimal voltage hysteresis ($\sim 0.35 \text{ V}$), and remarkable cycling stability over 2500 cycles at (1.0 C) outperforming its dehydrated counterpart. When paired with hard carbon in full pouch cells, the system delivered an energy density of $144.2 \text{ Wh}\cdot\text{kg}^{-1}$ (power density $2871.3 \text{ W}\cdot\text{kg}^{-1}$) with 83.71% capacity retention after 500 cycles. These findings highlight the pivotal role of precursor kinetics in tailoring defect chemistry and electrochemical stability of Ni-HCF-based positrodes, offering valuable design insights for high-performance sodium-ion pouch cells.

Acknowledgements: This research received support from the Basic Science Research Program (2022R1A2C2010339) and the Regional Leading Research Center Program (2019R1A5A8080326) through the National Research Foundation funded by the Ministry of Science and ICT of the Republic of Korea.

Biography:

Nam Hoon Kim is the professor in Nano Convergence Engineering Department, Jeonbuk National University, South Korea. His current research area focuses on the developing functional composites & nanocomposites and advanced nanomaterials for energy storage and conversion technologies (supercapacitors, Li-ion battery, solar cells, fuel cells, and water electrolysis). He has a strong research achievement record in the field with more than 300 SCI papers, which have reached the citation of more than 40000 times and with an h-index of 101.

Development of Printed Circuit Board Materials Using Bio-Based Raw Materials

Yohei Ito, and Koji Shibuya

Abstract:

Printed circuit boards (PCBs) are used in various electronic devices; however, the coexistence of diverse resins and metals complicates their separation and recovery processes. As a result, recycling is currently challenging from an economic perspective, leading to significant amounts being discarded. In response to the need for a low-carbon society, we are working on the development of PCBs using bio-based materials. While there have been instances of applying biomass materials to the matrix resin of PCBs and using natural fibers as reinforcement, there are still few examples of applying bio-based materials to both the reinforcing fibers and matrix resin of PCBs. Our goal is to develop rigid PCBs that serve as alternatives to conventional glass-epoxy boards, which typically use glass fibers as reinforcement and epoxy resins as the matrix, by incorporating bio-based materials into both components. The manufacturing of rigid PCBs requires a lamination process, necessitating the use of prepregs that are pre-impregnated with uncured matrix resin for handling. Therefore, we successfully created a prepreg by mixing conventional epoxy resin with bio-based epoxy resin to suppress flow at room temperature and by compounding it with natural fibers such as flax or ramie. By laminating and thermally curing these prepregs, we prototyped substrate materials suitable for rigid PCBs. Furthermore, we evaluated their mechanical and electrical properties. This presentation will report on these results.

Biography:

Yohei Ito is a head researcher at Mitsubishi Electric Corporation. He is engaged in the development of metal matrix composites, fiber-reinforced plastics, and printed circuit board materials. Additionally, he is involved in exploring the application of these materials to in-house products.

Modified Aluminum Powders with Enhanced Reactivity for Energy Systems

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Abstract:

Aluminium (Al) is widely used as a metallic fuel in composite solid propellants due to its high mass heat of oxidation, significant density, and corrosion resistance. Current research focuses on the composition and structure of materials to improve efficiency and functionality.

One of the practical approaches is the introduction of graphite as a solid functional modifier. Due to its high thermal conductivity and chemical inertness, graphite intensifies heat exchange between the exothermic reaction zone and aluminum particles, accelerating the heating and destruction of the oxide shell. Additionally, the graphite modifier acts as a mechanical separator, which reduces the average diameter of the formed agglomerates and increases the completeness of metal oxidation.

As a result of the research conducted, optimal conditions for the mechanochemical processing of aluminum with the addition of graphite were determined, allowing for a significant improvement in its thermoreaction characteristics for use in energy systems. It has been established that MCT destroys the oxide film, increases the proportion of active aluminum (from 80.52 to 92.90%), and shifts the central exothermic oxidation peak from 662.6 to 653.9°C, contributing to accelerated ignition. It was found that adding 10% C ensures optimal dispersion of particles, increases thermal conductivity, and suppresses agglomeration. At the same time, the average size of Al crystallites decreases, and a uniform carbon layer is formed, which, according to TG/DTA data, leads to the complete combustion of aluminum and increased energy efficiency of materials. At a content of 20% C, the proportion of active Al decreases to 74.30%, the carbon protective film is preserved, but structural heterogeneity occurs, and the enthalpy of the reaction decreases, which is associated with dilution of the active phase and shielding of aluminum areas. Thus, an approach has been developed in which the introduction of graphite in an optimal content allows for the simultaneous stabilization of the structure and activation of aluminum, ensuring more complete combustion and increased efficiency of energy systems

Biography:

Bakkara A.E. – PhD, Associate Professor, Leading Researcher at the Institute of Combustion Problems. Senior Lecturer, Department of Chemical Physics and Materials Science, Farabi University.

Development of Cascade Catalyst for Sustainable Production of Even-Numbered Paraffins from Biomass-Derived Fats and Oils

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Climate Change Research Division: Korea Institute of Energy Research, Yuseong-gu, Daejeon, Korea (South)

Abstract:

Even-numbered paraffins with relatively high melting points and stable physical properties are important precision chemical raw materials that support various markets such as waxes, lubricants, plastics, and advanced materials. With the growing demand for sustainable and ecofriendly products, ensuring a reliable supply of these paraffins has become increasingly critical. Traditional production methods generally involve noble metal-based deoxygenation reactions—including decarbonylation and decarboxylation—that yield a mixture of odd- and evennumbered paraffins, limiting selectivity and overall process efficiency.

In this study, we developed cascade catalysts aimed at the highly selective production of evennumbered paraffins from biomass-derived fats and oils, a renewable and sustainable feedstock. Unlike conventional approaches, our catalysts utilize inexpensive transition metals to sequentially perform hydrogenation, dehydration, and hydrogenation reactions within a single catalytic system. This cascade reaction strategy achieved nearly complete conversion (100%) and excellent even-paraffin selectivity (over 95%).

To advance practical applications, we focused on catalyst shaping for scale-up suitable for commercial use and optimized reaction conditions through rigorous parameter testing. Additionally, various catalyst characterizations were conducted to better understand the reaction mechanisms.

Biography:

Dr. Il-Ho Choi earned his Ph.D. in Sustainable Aviation Fuel Production from the Department of Chemical and Biological Engineering at Korea University in 2024. Since 2018, he has been a senior research engineer at the Climate Change Research Division of the Korea Institute of Energy Research. His research focuses on the efficient utilization of energy resources and the production of eco-friendly fuels, including sustainable chemical feedstocks from biomass, catalytic reactions, liquid fuels, reforming and hydrogen production, energy resource refineries, and bio-aviation fuel.

Biomass Waste for the Preparation of rGO-Like Carbon/TiO₂ Composites Derived from Cassava Residue for Counter Electrodes in Dye-Sensitized Solar Cells

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Abstract:

Industries utilizing cassava-derived products generate a large amount of waste during production, cassava residue (CR), yeast fermented cassava residue (YCR), cassava peel (CP) and yeast fermented cassava peel (YCP). To address this biomass waste issue while creating value-added materials, reduced graphene oxide (rGO) was synthesized from these wastes using a modified Hummers' method. The rGO-like carbon was mixed with titanium dioxide (TiO₂) to enhance its properties and subsequently coated onto FTO glass substrates using the doctor blade technique. This composite material was specifically designed to function as a counter electrode (CE) in dye-sensitized solar cells (DSSCs), offering a sustainable approach to renewable energy solutions. The DSSCs based on rGO-like carbon/TiO₂ composite derived from cassava peels achieved a power conversion efficiency (PCE) of 6.76%, with an open-circuit voltage (V_{oc}) of 0.76 V, a short-circuit current density (J_{sc}) of 15.88 mA/cm², and a fill factor (FF) of 0.76.

Biography:

A researcher in physics at Thammasat University of Thailand, with strong expertise in emerging photovoltaic technologies, nanomaterials, and natural material applications. Research interests include dye-sensitized and perovskite solar cells, carbon quantum dots, and renewable energy systems. With 48 international publications (h-index 17, Scopus) and over 50 peer reviews, the work has received national thesis awards, recognition as a distinguished alumnus recognition from Khon Kaen University, and the Thammasat University Young Researcher Award. Research has been supported by major funding bodies such as NRCT, PMU-B, TSRI, and the Ministry of Energy, focusing on advanced materials, sustainable energy, and green innovation.

Desalination Performance of MIL-68(In) MOF-Filled PVDF Membranes in Vacuum Membrane Distillation

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⁷Institute on Membrane Technology, National Research Council of Italy (CNR-ITM), Via P. Bucci 17/c, 87036 Rende, CS, Italy

Abstract:

This study investigates the potential of MIL-68(In), a metal-organic framework (MOF), to enhance the desalination performance of hydrophobic PVDF membranes in vacuum membrane distillation (VMD). Using non-solvent induced phase separation, we successfully synthesized highly stable, porous, and selective MIL-68(In) integrated PVDF membranes. The effect of varying MOF loadings (0.25, 0.5, 1.0, and 2.0 wt.%) on total permeate flux and salt rejection was assessed at different operating temperatures. Additionally, the membranes were characterized using water contact angle measurements, scanning electron microscopy (SEM), mechanical testing, x-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and pore size analysis, revealing significant enhancements in desalination performance and membrane properties. The membrane presenting the highest MIL-68(In) loading (2wt%) revealed an exponential increase in permeate flux while maintaining the high salt rejection rates (over 99.7%) with performance stability of 72 hours. The experimental results indicate that MIL-68(In) modified PVDF membranes could be an important material for the preparation of VMD desalination membranes.

Biography:

Roberto Castro Muñoz is an enthusiastic researcher with main interests and expertise in membranes and membrane processes for environmental applications, focusing on water purification and energy-relevant gas mixtures. He currently holds the position of Associate Professor at the Gdansk University of Technology (Poland). To date, Roberto has published over 200 articles in international scientific journals with an H-index of 60. His current project is oriented to design and characterize hybrid membranes containing nanoporous inorganic materials for selective molecular separations.

Functionalized Natural and Waste-Derived Zeolites for Elemental Mercury Control: Activation Strategies and Structural Considerations

Piotr Kunecki*, and Magdalena Wdowin

Mineral and Energy Economy Research Institute, Polish Academy of Sciences, Kraków, Lesser Poland, Poland

Abstract:

The mitigation of elemental mercury (Hg^0) emissions from industrial gas streams remains a critical challenge due to the element's volatility, persistence, and toxicological impact. This study explores the potential of natural and waste-derived zeolitic materials as sorbents for Hg^0 capture, focusing on

activation pathways and structural features relevant to their adsorption performance. In the first phase of the research, natural zeolites were modified using two activation approaches: surface spraying and ion exchange, with silver and iron introduced in both nitrate and chloride forms. The modified materials were characterized via PXRD, SEM-EDS mapping, and FTIR spectroscopy. Sorption tests for Hg⁰ were conducted using a custom-designed laboratory setup across six consecutive adsorption cycles. To assess long-term retention, selected samples were analyzed twelve months post-sorption using a direct mercury analyzer (DMA-80 evo), providing insight into mercury stability and possible re-emission. In parallel, synthetic zeolites were successfully synthesized from post-consumer glass via a two-step hybrid process involving alkaline fusion with NaOH followed by hydrothermal crystallization in the presence of activation precursors. The resulting materials, primarily of the zeolite A type, have been structurally characterized and are currently being prepared for future mercury adsorption testing. The results obtained so far demonstrate that ion exchange—particularly with nitrate-based precursors—yields superior incorporation of active species and improved mercury retention. These findings highlight the influence of precursor chemistry and activation technique on sorbent performance. The integration of waste-derived materials into this approach aligns with circular economy principles and opens new avenues for sustainable mercury control technologies.

Acknowledgements: This research was supported by the National Science Centre (NCN), Poland, under project no. 2021/41/N/ST5/03214.

Biography:

Piotr Kunecki completed his MSc studies in 2014 at AGH University of Science and Technology in Krakow, Poland. In 2015-2018, he worked as a research assistant at the Lublin University of Technology, taking part in two research projects. From 2017, he started working as a research assistant at the Mineral and Energy Economy Research Institute of the Polish Academy of Sciences, where in October 2021 he defended his doctorate and started working as an assistant professor. From January 2021, he is also prime investigator of the project supported by the National Science Center, Poland, grant no. 2021/41/N/ST5/03214.

Sustainable Materials for Purification of Effluents from Wastewater Treatment Plants by Permeable Reactive Barriers

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Abstract:

Water worldwide is becoming an increasingly valuable and vulnerable resource due to its depletion and contamination by human activities. Both untreated and treated municipal wastewater is commonly released to surface water bodies, including streams and reservoirs, representing a source of contamination that may end up compromising water quality. Contaminants of emerging concern (CECs), such as pharmaceuticals, personal care products, antibiotics and their metabolites, are commonly found in municipal wastewater effluents, due to their persistent nature in conventional biological

treatment processes. Present disposal of wastewater effluents in structures built on sandy high permeability soils presents an opportunity to develop treatment solutions to remove CECs from these effluents by installation of horizontal permeable reactive barriers. These structures are barriers through which the effluent waters should flow, constituted by materials (fillers) that passively capture the contaminants, removing or degrading them by adsorption, precipitation, or chemical reaction, releasing uncontaminated water with quality to be reused. The selection of proper materials, as adsorbents and catalysts, is thus crucial in the development of permeable reactive barriers as solutions for the removal of CECs from effluents of wastewater treatment plants.

In this work low-cost and sustainable materials were developed, as biochar and activated carbon prepared from agro-industrial wastes, with their physico-chemical properties tuned to be used as reactive fillers in permeable reactive barriers, integrated as environmental treatment solutions. Experiments included the synthesis and characterization of biochar and activated carbon using biomass agro-industrial wastes, by pyrolysis and activation procedures, the monitorization of targeted CECs and assessment of the quality of the waters collected at the exit of the barriers to ensure that water is of sufficient quality to be used for irrigation. Results obtained show that permeable reactive barriers can be constructed and used as cost-effective and sustainable water treatment solutions, especially when considering materials derived from wastes.

Biography:

Kalmakhanova M.S. is associate professor at M.Kh. Dulaty Taraz University. Since her PhD studies in Chemistry, concluded in 2019 in collaboration with Bragança Polytechnic Institute, Portugal, she has continued involvement with environmental science research activities, specifically focused on the synthesis and characterization of adsorbents and catalysts to solve water environmental problems. She was awarded several prizes and recognitions, as best university teacher in 2022, supervised several projects, performed internships in Portugal, Spain and USA. Presented her work at international conferences in Spain, Greece, Japan, Check Republic, USA and Austria, and authored over 50 publications in scientific journals and conference proceedings.

Biofuel Cell based on Photosynthetic Reaction and its Application to Architecture

Yasumitsu Matsuo, Hitoki Semizo, and Hinako Kawakami

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Abstract:

Biomaterials are promising materials that can reduce environmental load. In the energy sector, fuel cells utilizing inexpensive waste biomaterials such as discarded plants are anticipated as next-generation clean energy to realize a carbon-neutral, zero-emission society. As is well known, in the initial reactions of photosynthesis, water splitting within the photosystem II (PSII) complex generates protons, electrons, and oxygen. Therefore, the protons and electrons obtained from photosynthetic reactions can be utilized as hydrogen fuel for fuel cells. In this study, we extracted the PSII complex from plant leaves as a solution and investigated hydrogen fuel generation. Furthermore, a biofuel cell utilizing the bioelectrolyte “chitin” and hydrogen fuel derived from the photosynthetic reaction was fabricated, and its power generation characteristics were examined. The results revealed that hydrogen is generated by the photosynthetic reaction in the PSII solution, and that the biofuel cell utilizing photosynthetic hydrogen fuel demonstrates

a power density of 1.2 W/m^2 . These results suggest that biofuel cells utilizing waste biomass ‘chitin’ and “chloroplasts” could become a next-generation sustainable energy source. Furthermore, we also attempted to create a “photosynthetic architecture” for generating hydrogen energy. As a result, we can successfully fabricate architectural elements, such as a window, that can produce hydrogen energy from biomaterials.

Biography:

Dr. Yasumitsu Matsuo is a professor at Setsunan University. He has taken a doctorate in science by photoconductivity in GeO_2/Ge film, and thereafter has also investigated the mechanism of proton conductivity. In recent years, he has focused on the potential of biomaterials as proton conductors and has investigated environmentally friendly biofuel cells with bio-electrolytes. Particularly, he investigates technologies to create not only the fuel cell itself but also the hydrogen fuel from the discarded biomaterials. Currently, he is not only developing biofuel cells but also implementing architecture that generates electricity by photosynthesis.

Additive Manufacturing of Boron-Based Functional Ceramics for Photocatalytic Applications

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Abstract:

In recent years, there has been a growing interest in ceramic materials and their derived 3D structures, owing to their outstanding mechanical, chemical, and thermal properties. We present a novel approach for fabricating robust ceramic SiOC 3D microstructures by combining precursor synthesis, laser lithography, and pyrolysis. Hybrid organosilicon precursors, prepared using trimethoxymethylsilane and 3-(trimethoxysilyl)propyl methacrylate through a sol-gel method, enable laser photopolymerization due to the acrylate functional group. After high-temperature pyrolysis under a nitrogen atmosphere, hard ceramic objects with exceptional mechanical properties are achieved, surpassing those of soft organometallic derivatives. The attained mechanical properties and tunability of materials, including amorphous SiOC and crystalline SiC, α, β -Si₃N₄, represent a significant advancement in manufacturing mechanically robust devices. Notably, the our prepared MTMS:MAPTMS 8:2 material annealed at 1200 °C exhibits a hardness of $14.33 \pm 1.17 \text{ GPa}$, a reduced elastic modulus of $104.99 \pm 1.81 \text{ GPa}$, low density of $2.21 \pm 0.09 \text{ g/cm}^3$, and an amorphous SiOC state. This material is ideal for pressing molds in micro-optic fabrication using fused quartz and for producing microscopic apertures due to its opacity. In summary, the results highlight multi-photon lithography and thermal post-processing as a powerful tandem for creating ultra-resilient multifunctional 3D microscale ceramic structures. These achievements effectively tackle the challenges associated with producing solid and precise 3D structures, expanding the potential applications of this technology in the industry. Greta Merkininkaitė acknowledges the financial support from the Research Council of Lithuania (LMTLT) Fund (project No S-PD-24-40).

Biography:

Dr. Greta Merkininkaitė gained a Bachelor’s degree in Nanotechnology and Materials Science (2016) and

a Master's degree in Chemistry of Nanomaterials (2018) at Vilnius University (VU). She obtained a PhD in 2023 after defending her doctoral dissertation "Additive Manufacturing of Inorganic 3D Nanostructures by Combining Laser Lithography and Pyrolysis" in the field of Materials Engineering in the area of Technological Sciences. Dr. Greta Merkininkaitė is an assistant professor at Vilnius University Faculty of Chemistry and Geosciences and a postdoctoral fellow at Center for Physical Sciences and Technology.

Cu-NH₂-MIL-125(Ti) Protected by PVDF for Hydrogen Production

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Department of Environmental Technology, Faculty of Chemistry, University of Gdansk, 80-308 Gdansk, Poland

Abstract:

The development of photocatalytically efficient, water-stable, and easily recoverable materials is a critical challenge in advancing solar-driven hydrogen production. In this study, we present a porous composite membrane based on Cu-incorporated NH₂-MIL-125(Ti), a titanium-based metal-organic framework (MOF), embedded within a poly(vinylidene fluoride) (PVDF) matrix. This novel composite successfully addresses key limitations of MOF photocatalysts - namely water instability, aggregation, and difficult recovery, through a simple fabrication strategy that immobilizes the MOF within a chemically resistant and mechanically robust polymer framework. To optimize the photocatalytic performance, the MOF loading within the PVDF matrix was systematically varied (1–10 wt%). A maximum hydrogen evolution rate of 389.1 $\mu\text{mol/h}\cdot\text{m}^2$ in aqueous triethanolamine (TEAO) and 466.0 $\mu\text{mol/h}\cdot\text{m}^2$ in acetonitrile (AcN)-based electrolyte was achieved with 10 wt% loading, representing a ~4.5-fold increase over the 1 wt% sample. The photocatalytic tests under UV-Vis irradiation revealed a direct correlation between MOF content and H₂ production efficiency, while also highlighting the composite's stability in strong alkaline environments over 20 hours of continuous operation. Scanning Electron Microscopy (SEM) and Energy-Dispersive X-ray (EDX) mapping confirmed the uniform dispersion and structural retention of MOF particles post-reaction, validating the PVDF matrix's role in preventing MOF leaching and degradation. This composite design also mitigates issues of photocatalyst aggregation and intermolecular quenching by spatially distributing the active sites throughout a porous polymeric scaffold. Overall, this study demonstrates a practical method to stabilize otherwise electrolyte-sensitive MOFs for efficient hydrogen production, offering a versatile platform for future integration of various MOFs into membrane-based photocatalytic systems. The results highlight the composite's potential for sustainable energy applications by facilitating clean hydrogen generation and reducing reliance on fossil fuels.

Biography:

Received her PhD degree in 2022 from Gdansk University of Technology. Since October 2022, she has worked at the University of Gdansk. She gained international experience in research laboratories in Italy, Mexico, and Turkey. Her expertise lies in the field of membrane technology, particularly in membrane fabrication and characterization and its application in water desalination. She is an author and co-author of 21 research papers in peer-reviewed journals, several book chapters, and oral presentations at National and International Conferences and Workshops.

Effects of Dopants on The Structural and Electrical Properties of Hafnium Oxide Thin Films Deposited by Atomic Layer Deposition

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National Institute for Research and Development in Microtechnologies, IMT-Bucharest, 126A Erou Iancu Nicolae Street, 077190 Voluntari, Ilfov, Romania

Abstract:

Atomic Layer Deposition (ALD) has been widely used due to its ability to grow thin films with a precisely control of thickness and uniformity, key factors for the production of high-performance materials used in microelectronics and optoelectronics. Present work investigates the ALD processes of hafnium oxide (HfO_2) thin films fabrication, and impact of aluminium (Al), zirconium (Zr), yttrium (Y) dopants on the HfO_2 matrix characteristics. Additionally, the varying of thicknesses of the films were used to explore the change in electrical properties. The structural evolution of the films is examined using a range of advanced characterisation techniques, including Grazing Incidence X-ray Diffraction (GIXRD) for phase identification, X-ray Reflectivity (XRR) to assess film thickness and density, and Atomic Force Microscopy (AFM) for surface morphology analysis. Furthermore, Scanning Electron Microscopy (SEM) is employed to observe the microstructure of the films at the nanoscale. Electrical properties are characterised through capacitance-voltage (C-V), current-voltage (I-V) measurements to determine the dielectric behaviour and charge transport characteristics of the doped films. The influence of dopants on crystallinity, stoichiometry, or defect density is correlated with the electrical performance of the thin films. The results demonstrate that doping with Al, Zr, and Y changes the structural integrity and enhances the material properties, making these films suitable for use in advanced electronic devices. This work provides valuable insights into how doping and film thickness can be optimised to improve the performance of HfO_2 -based materials.

Biography:

Florin NĂSTASE is a senior research physicist at IMT Bucharest, Romania. In 2003, he obtained his master's degree in Polymer Physics from the University of Bucharest. In 2007, he earned a PhD in Physics from the same university for his research on functional molecular architectures developed on π -conjugated oligomer/polymer structures. His current research interests include the synthesis of ultra-thin films using methods such as atomic layer deposition and plasma polymerization, with applications primarily in organic semiconductors, high-k dielectrics, ferroelectrics, nanocomposites, nanolaminates, and hybrid thin films.

Effect of the Zr/Ti Ratio on the Properties of $\text{Ba}(\text{Zr}_x\text{Ti}_{1-x})\text{O}_3$ Ceramics with a Perovskite-Type Structure

Jolanta Makowska*, Małgorzata Adamczyk-Habrajska, and Beata Wodecka-Duś

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Abstract:

$\text{Ba}(\text{Zr}_x\text{Ti}_{1-x})\text{O}_3$ (BZT)-based ceramics belong to the family of ferroelectric perovskite materials that exhibit significant potential in electronic applications, particularly in capacitors, transducers, actuators, and

sensors. This study focuses on the synthesis and fundamental characterization of BZT ceramics obtained via conventional solid-state reaction methods. The preparation process involved mixing and calcining appropriate oxides or carbonates, followed by sintering of the resulting powders under controlled conditions. Structural (XRD), microstructural (SEM), and dielectric measurements were carried out to investigate the influence of zirconium (Zr) content on the material's properties. The results indicate that adjusting the Zr/Ti ratio enables precise tuning of the phase transition temperature and dielectric parameters, making BZT ceramics a promising lead-free alternative for use in modern, environmentally friendly electronic devices.

Biography:

Jolanta Makowska research interests center on modern functional materials, particularly perovskite-structured compounds and multilayer Aurivillius phases. These materials exhibit unique dielectric, piezoelectric, and magnetic properties, making them highly relevant for applications in sensors, actuators, capacitors, fuel cells, and ferroelectric memory. She focuses on modifying their chemical composition through rare earth ion doping to tailor their functional behavior. She applies advanced characterization techniques such as impedance spectroscopy, X-ray diffraction (XRD), and scanning electron microscopy (SEM). For her, linking fundamental materials research with practical applications is essential in advancing technology.

Preparation and Characterization of $\text{Ba}_{0.996}\text{La}_{0.004}\text{Ti}_{0.999}\text{O}_3$ Perovskite Ceramics Doped with Special Glass

Beata Wodecka-Dus*, Jolanta Makowska, and Malgorzata Adamczyk-Habrajska

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Abstract:

The wide range of interesting properties exhibited by $\text{Ba}_{0.996}\text{La}_{0.004}\text{Ti}_{0.999}\text{O}_3$ ceramics, demonstrating highly impressive dielectric and electrical characteristics from both a fundamental research and application standpoint, undoubtedly deserves diversification and optimization. To this end, a modification of the aforementioned ceramics with a lead-borosilicate special glass from the $\text{PbO-B}_2\text{O}_3\text{-Al}_2\text{O}_3\text{-WO}_3$ system has been proposed.

The novel ceramic materials were obtained through a method based on powder synthesis from simple oxides in the solid state, followed by densification via free sintering. All ceramic powders underwent thermal analysis (TG/DTA) as well as differential thermogravimetric analysis (DTG). The crystal structure and qualitative and quantitative phase identification of both the special glass and the doped $\text{Ba}_{0.996}\text{La}_{0.004}\text{Ti}_{0.999}\text{O}_3$ ceramics were examined using X-ray diffraction (XRD). The Rietveld method was applied to determine the unit cell parameters. X-ray diffraction analysis (XRD) of the obtained materials confirmed a single-phase tetragonal structure with the space group $P4mm$. A uniform deformation of the tetragonal parameter was observed after the addition of glass. The influence of the glass admixture on the microstructure of the obtained ceramic materials was observed using a scanning electron microscope (SEM). With increasing glass content, a reduction in grain size and denser packing of grains were noted. The addition of glass caused a decrease in dielectric permittivity across the entire considered temperature range and a slight increase in the dielectric loss tangent. However, it is worth

noting that both values remain attractive for potential applications. Moreover, this modification increases dielectric dispersion across all studied temperature ranges, which is highly valuable for electromagnetic wave absorbers. Based on the dielectric measurement results, the Curie-Weiss temperature (T_0) and the Curie constant (C) were also determined. The addition of a glassy phase admixture to ceramic materials creates opportunities for tailoring and optimizing their properties for specific applications, leading to improved performance and functionality.

Biography:

Beata Wodecka-Dus research interests center on modern functional materials, particularly perovskite-structured compounds, multilayer Aurivillius phases, and materials doped with special glasses. These systems exhibit unique dielectric, piezoelectric, piezoresistive and magnetic properties, relevant for advanced technologies such as sensors, actuators, capacitors, fuel cells, and ferroelectric memory. She focuses on modifying their composition through rare earth ion and glass doping to enhance functional behavior. She uses advanced characterization techniques like impedance spectroscopy, XRD, and SEM. Bridging fundamental research with real-world application is a key aspect of her scientific work.

Graphene-Based Inks with Controlled Antibody Orientation via Hydrazone Bond for Enhanced Biosensing Applications

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Abstract:

Biosensor development is critical for advancing point-of-care diagnostics by enabling the rapid acquisition of medical data directly at the site of care, thereby reducing the time needed for diagnosis. In this field, immunosensors are of extreme importance. These devices take advantage of the specificity of antigen–antibody interactions to accurately detect target biomarkers. Their exceptional sensitivity to target molecules renders them indispensable for early disease diagnosis.

Graphene and its derivatives have emerged as promising materials in the development of biosensors. Their high surface area, excellent electron transport capabilities, and unique electronic properties significantly enhance sensor sensitivity and selectivity.¹ Furthermore, these attributes facilitate real-time monitoring, making graphene-based platform ideal for detecting disease biomarkers and integrating into wearable health technologies.

A critical step in the fabrication of immunosensors is the bioconjugation of antibodies. Traditional approaches typically employ carboxylic acid groups, either naturally present or chemically introduced, to link antibodies via amidation reaction that targets the free amines in antibody side chains.² However, these methods often result in non-directional antibody attachment, which can compromise the biosensor performance by reducing effective antigen recognition.

Recent advancements in flexible electronics have driven a transition from rigid sensor frameworks to conductive inks applied via inkjet printing, a cost-effective alternative. Graphene-based inks are particularly attractive not only for their intrinsic properties but also for their potential for industrial-scale production through electrochemical exfoliation.

In this study, we focus on preparing a graphene-based ink that has been chemically modified to incorporate acylhydrazine groups. These groups enable controlled antibody anchoring by reacting with aldehydes formed from the oxidized glycan moieties on the antibody heavy chain, thereby forming hydrazone bonds that ensure uniform antibody orientation and minimize protein inactivation.³ Finally, the ink's viscosity and surface tension were optimized to meet the stringent requirements of inkjet printing, and its properties were comprehensively evaluated.

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Biography:

Pinotti Riccardo, currently a postdoctoral researcher in the NanoSelf group at the University of Coruña, specializing in graphene functionalization and ink formulation. He earned my PhD in 2024 from the University of Strasbourg under the supervision of Cecilia Ménard-Moyon and Ali Abou-Hassan. His doctoral research focused on the use of carbon nanotubes and plasmonic nanoparticles for biomedical applications, particularly in the treatment of cancer and rheumatoid arthritis.

Technological Optimization of MXenes' Dielectrophoretic Alignment within Polar Solvents

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Abstract:

As of their large specific surface area, chemical stability, hydrophilicity, and high mechanical, electrical, and physicochemical properties, MXenes are an ideal candidate for the development of high-performance polymeric composites. In particular, MXenes' alignment has recently attracted academia's interest, as this technological procedure may reinforce the properties of composites, which can be easily tuned based on ordered or reordered direction(s).

Within the herein work, we are presenting the functionality of dielectrophoresis (DEP) as a means for facile, robust, and durable alignment of MXene flakes within various composites. The influence of different dispersion polar solvents (e.g., H₂O, ethanol, DMF, and DMSO) on composite properties is investigated and discussed. The most important intrinsic (solvent conductivity) and extrinsic

(dielectrophoretic parameters) factors were varied in order to achieve optimal (parallel to the electric field direction) alignment/orientation of MXenes. Moreover, suitable values of the signal frequencies for avoiding parasitic electrokinetic phenomena (AC electro-osmosis, electrothermal effect) occurring simultaneously with DEP were identified.

Biography:

Ina Turcan is Assistant Professor of Biophysics at the Iasi University of Life Sciences. She received the B.Sc. degree in medical physics from “Alexandru Ioan Cuza” University of Iasi, Romania, in 2014 and started her research activity in the field of multifunctional composite materials during the master's program. She earned her Ph.D. degree in Physics from the “Alexandru Ioan Cuza” University of Iasi in 2021. Her research is based on a multidisciplinary approach by combining basic physics knowledge with applied physics aspects and has a strong background in multiple research components (synthesis of composite material, physico-chemical properties characterization, and electromanipulation of target objects).

Enhancing Performance Behavior of Polybutylene Succinate Composites with Antimicrobial Chitosan Additives

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Abstract:

Biobased and biodegradable polymer composites hold great potential to become perspective future materials for broad range of applications. Unfortunately, many of natural biomaterials lack thermal stability and they are sensitive at high shear conditions. Consequently, in the current research it is reported on the development of biobased polybutylene succinate copolymer (PBSA) hybrid composites with different antimicrobial chitosan additives and nanoclay. It is demonstrated that addition of nanoclay allows to increase stiffness, strength and thermal resistance as well as improve rheological behavior of the developed hybrid composites. On the other hand, addition of high deacetylation degree fungal chitosan oligosaccharide is especially efficient in ensuring antimicrobial properties of the developed hybrid composites. Manufacturing of extrusion blown films from the developed hybrid composites is also demonstrated.

Acknowledgements: This research was funded by the Latvian Council of Science, project “Smart Materials, Photonics, Technologies and Engineering Ecosystem” project No VPP-EM-FOTONIKA-2022/1-0001.

Biography:

Dr.sc.ing. Janis Zicans is leading researcher and founder of ISO/IEC EN 17025 accredited RTU Polymer Materials Testing laboratory, holding many years expertise in polymer technology.

Synergistic Effects of MWCNTs and Chemical Admixtures on the Foam Stability and Rheological Behavior of Lightweight Cement Pastes

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Abstract:

The development of lightweight and functional cement-based materials is essential for sustainable construction solutions. This study investigates the combined effect of multi-walled carbon nanotubes (MWCNTs), air-entraining admixtures (AEAs), and three types of superplasticizers – lignosulfonate (LS), polyacrylate (PA), and polycarboxylate ether (PCE) – on the foam stability and rheological behavior of cement pastes. MWCNTs, known for their high surface area and bridging capabilities, were shown to significantly enhance foam stability and suspension viscosity by forming filament-like networks that entrap air bubbles. When used together with AEAs, a pronounced synergistic increase in viscosity and initial foam volume was observed, especially at higher MWCNT dosages (up to 0.5% bwoc). However, the effectiveness of this synergy was found to be highly dependent on the type of superplasticizer. SP(LS) preserved foam stability, while SP(PA) and SP(PCE) reduced it due to interference with bubble formation. Electrical conductivity and setting time measurements revealed that increasing MWCNT content delays hydration, reduces ion mobility, and extends setting time up to 2.8-fold in the presence of PCE. Spreadability tests confirmed a reduction in flowability with MWCNTs, partially recovered by SP(PCE). Overall, this work presents new insights into multicomponent nano-admixture interactions and highlights pathways for tailoring foamed cementitious systems for structural and thermal efficiency.

Biography:

Jolanta Pranckevičienė, PhD is a Senior Researcher at Vilnius Gediminas Technical University (VILNIUS TECH). Research focuses on ecological and modified construction materials, recycling of waste and industrial by-products, geopolymerization, and durability testing. Expertise includes innovative treatment and utilization of secondary raw materials in building applications, such as lightweight ceramics, refractory materials, geopolymers, and concrete. Active participation in international research collaborations, funded projects, and scientific dissemination activities.

Synthesis of N, B-Doped Carbon Quantum Dots from Spruce Lignin and their Use as a Temperature Probe

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Abstract:

The valorization of biomass into functional nanomaterials presents an alternative strategy for developing various luminescent materials, which are currently primarily prepared from rare-earth-doped materials. The extraction and processing of rare-earth metals are associated with high energy consumption, the generation of radioactive waste, and ecological damage. So, there is an urgent need for the use of renewable biomass material alternatives. One of the alternative materials is carbon quantum dots (CQDs) derived from biomass, especially from lignin, an aromatic polymer. Lignin has benzene rings, hydroxyl, and methoxy groups, which are natural precursors for conjugated carbon domains and can be easily transformed into CQDs. Biomass prepared CQDs have many advantages: enhanced quantum yield after heterodoping, low cost, low toxicity, and possibility for design of multifunctional nanomaterials.

In our work, spruce lignin, an abundant and renewable byproduct of the pulp and paper industry, was employed as a carbon source for the synthesis of nitrogen- and boron-co-doped carbon quantum dots (N, B-CQDs) via a simple two-step hydrothermal process. The size, degree of graphitization, and versatility of functional groups of N, B CQDs were tuned with the first step of reaction, acidolysis. Our work aimed to show how structural differences of N, B CQDs notably influenced their luminescence properties and how the prepared N, B-CQD can be tested as luminescent temperature probes.

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Biography:

Jelena Papan Djaniš is a Research Fellow at the Chair of Inorganic Chemistry within the Faculty of Chemistry and Chemical Technology, University of Ljubljana in Slovenia. Her work focuses on the synthesis, functionalization, and stabilization of magnetic and luminescent nanomaterials, currently with a focus on biomass-based luminescent nanomaterials. She is leading international projects, notably in collaboration with Polish partners under the Weave-UNISONO funding program. She is an author and co-author of 28 scientific papers, with a h-index of 14.

Eu³⁺-Doped Sr₂LaF₇ Nanopowders for Indoor Plant Growth LED Applications

Lj. Đačanin Far*, B. Milićević, J. Periša, A. Ćirić, K. Milenković, S. Kuzman, and M.D. Dramićanin

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Abstract:

Phosphor materials emit light upon energizing by an external source through a process of luminescence, when the material absorbs energy and re-emits it as visible light or in other wavelengths, like ultraviolet or infrared. Lanthanide-based phosphors emit electromagnetic radiation across wide spectral range, making them versatile components for developing innovative technologies. For the use in agriculture, phosphors in the form of an efficient plant-growth-targeted light-emitting diode (LED) must convert as much electrical energy as possible into Photosynthetically Active Radiation (PAR) region, the spectral range of solar radiation from 400 to 700 nm that organisms can use in the process of photosynthesis. In this research, a series of Sr₂La_{1-x}Eu_xF₇ (x = 0, 0.05, 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 0.6, 0.8) phosphor nanopowders were prepared using a hydrothermal method. Powder X-ray diffraction analysis confirmed

that the materials crystallize in a cubic crystal structure. Transmission electron microscopy shows quasi-spherical nanoparticles with an average particle size of ~36 nm. Photoluminescence measurements show highly efficient red emission, with the optimal concentration of 50 mol% of Eu^{3+} , after which the concentration quenching occurs. The most prominent emission peaks are around 600 nm (orange/red) and 700 nm (deep red). The observed 5D0-level lifetimes are long, they gradually decrease from 15.3 ms for $x = 0.05$, as the Eu^{3+} concentration increases. Reflected electron energy loss spectroscopy method was used to determine the band gap of the Sr_2LaF_7 sample to be 8.8 eV. The combination of the high efficiency of emission, large band gap, as well as the atypical dominant deep-red emission at 700 nm labels these samples as potential nanophosphors for indoor plant growth LED applications.

Biography:

Dr. Ljubica Đačanin Far obtained her PhD from the Physics Department, Faculty of Sciences, University of Novi Sad, Serbia. Her scientific career started in 2006 at the Faculty of Sciences. She has worked at Vinča Institute of Nuclear Sciences since 2021. Her research is focused on the development of novel and innovative routes for nanopowders synthesis, and structural and optical characterization of rare earth and transition metal doped nanopowders, ceramics and sensors. Her research has resulted in 31 publications in international peer reviewed journals with 700 citations and h index of 12, (source: www.scopus.com, April 2025).

Deep-Red Emitting $\text{Mg}_2\text{TiO}_4\text{:Mn}^{4+}$ and $\text{Ag@SiO}_2\text{:Mg}_2\text{TiO}_4\text{:Mn}^{4+}$ Nanoparticles

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Abstract:

We present the synthesis, structure, morphology, detailed spectroscopic, and crystal-field analysis of Mn^{4+} -doped Mg_2TiO_4 nanoparticles (NPs) and $\text{Mg}_2\text{TiO}_4\text{:Mn}^{4+}$ phosphor containing core@shell Ag@SiO_2 NPs. Transmission electron microscopy confirms that the former NPs, obtained through a Pechini-type polymerized complex route and calcination at 600 °C, have a diameter of approximately 10 nm. The strong, sharp red emission from these NPs at 658 nm is caused by the tetravalent manganese ions going through a spin-forbidden ${}^2\text{E}_g \rightarrow {}^4\text{A}_{2g}$ electron transition. We use the exchange-charge model to calculate the energy levels of the Mn^{4+} ions in a trigonal crystal field of Mg_2TiO_4 , which match well with the experimental photoluminescence excitation and emission spectra. The calculated crystal-field parameters (CFPs) have the same absolute values as those found for trigonal point symmetry at Mn^{4+} dopant sites ($\text{Y}_2\text{Ti}_2\text{O}_7$, $\text{Y}_2\text{Sn}_2\text{O}_7$, and Na_2SiF_6). We also observed that covalent and exchange effects contribute nearly eight times more to the CFPs than the point-charge contribution. The plasmon enriched red phosphor, which includes core@shell Ag@SiO_2 and $\text{Mg}_2\text{TiO}_4\text{:Mn}^{4+}$ NPs, is synthesized using low-temperature annealing of a sol-gel host precursor. The luminescence of Mn^{4+} exhibits a nonmonotonic dependence on the size and concentration of 40 and 70 nm silver nanoparticles. The luminosity of the $\text{Mg}_2\text{TiO}_4\text{:Mn}^{4+}$ phosphor is amplified up to 1.5 times when Mn^{4+} excitation is enhanced by localized surface plasmon resonance in Ag@SiO_2 nanoparticles. Ultimately, we show the red LED utilizing near-ultraviolet chip for excitation and this plasmonic phosphor.

Acknowledgment: This research was supported by the Science Fund of the Republic of Serbia, #GRANT No 7017, TECHNOLOGY FOR REMOTE TEMPERATURE MEASUREMENTS IN MICROFLUIDIC DEVICES – REMTES.

Biography:

Dr. Mina Medić obtained her PhD from the Faculty of Technology and Metallurgy, University of Belgrade after defending her dissertation. She has worked at The Vinca Institute of Nuclear Sciences since 2012. Her research is focused on the development of novel and innovative routes for nanopowders synthesis, and structural, morphological and optical characterization of rare earth and transition metal doped nanopowders (oxides, silicates, titanates, and titanium dioxide), ceramics and sensors. Her research has resulted in 29 publications in international peer reviewed journals (SCI list), with more than 840 citations, with an h index of 15, (source: www.scopus.com, April 2025).

Emission Enhancement by Bi³⁺ Co-Doping of Red-Emitting Nanophosphor for Horticulture LEDs

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Abstract:

Eu³⁺-activated inorganic phosphors are commonly used in general lighting and display technologies due to their typically strong orange-red (⁵D₀ → ⁷F_{1,2}) emissions with wavelengths shorter than 630 nm. However, phosphors activated by Eu³⁺ that strongly emit in the deep-red region - driven by the ⁵D₀ → ⁷F₄ transition - are relatively uncommon. These unique luminescent characteristics of Eu³⁺ are particularly suited to fulfilling the requirements of phytochrome photoreceptors in plants. Hereby we prepared Eu³⁺-activated Sr₂GdF₇ nanoparticles using the hydrothermal synthesis method. Transmission electron microscopy revealed quasi-spherical nanoparticles with an average particle size of ~24 nm. Atypically, photoluminescent measurements show strong red emission with intensity continually increasing with the Eu³⁺ content up to 80 mol%. The most prominent emission peaks are around 600 nm (red) and 700 nm (deep red). The Sr₂Gd_{0.2}Eu_{0.8}F₇ sample for Bi³⁺ co-doping was chosen, with the contents of 0.25, 1, 5, and 10 mol% of Bi³⁺ ions. Introducing Bi³⁺ caused significant enhancement of Eu³⁺ emission under a 391 nm excitation. The optimal co-doping concentration proved to be 1 mol% of Bi³⁺, inducing the integrated emission intensity increase by a factor of 2.5, compared to the non-codoped sample.

Very long emission lifetimes were observed, over 9 ms for the optimal sample. Judd-Ofelt analysis was performed to the emission spectra, unveiling that the emission enhancement originates from the non-radiative transition rate decrease with the Bi³⁺ addition.

Acknowledgment: This research was supported by the Science Fund of the Republic of Serbia, #GRANT No 10412, LED technology based on bismuth-sensitized Eu³⁺ luminescence for cost-effective indoor plant growth - LEDTECH-GROW. Authors acknowledge funding of the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia under contract 451-03-136/2025-03/ 200017.

Biography:

Dr. Sanja Kuzman, born on August 16, 1985, received her Ph.D. in Chemistry and Chemical Technology in 2012 from the University of Belgrade. Since then, she has worked at the Vinca Institute of Nuclear

Sciences. She currently holds the position of Senior Research Associate in the Optical Materials and Spectroscopy Group (OMAS). Her expertise includes inorganic chemical technology, materials synthesis, and luminescence spectroscopy. She has published 35 scientific papers and delivered over 40 poster presentations, and her work has been cited more than 990 times (h-index 15). Dr. Kuzman is also actively involved in journal reviewing and organizing scientific conferences.

Green Synthesis of Bimetallic Nanoparticles and their Catalytic Activity in the Degradation of Harmful Organic Dyes

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Babeş-Bolyai" University, Faculty of Chemistry and Chemical Engineering, Cluj-Napoca, Romania

Abstract:

Core-shell Au@Ag nanoparticles (NPs) have emerged as highly effective catalysts, especially for environmental applications. The green synthesis of these nanoparticles often uses plant phytochemicals such as flavonoids, phenolics, and terpenoids which act as both reducing and capping agents. A green method of synthesizing bimetallic nanoparticles using the aqueous goji fruit extract was developed. This core-shell structure enhances the surface plasmon resonance (SPR) and catalytic efficiency due to synergistic interactions between Au and Ag. The shell not only boosts the overall reactivity but also protects the gold core, ensuring long-term catalytic performance. The obtained bimetallic nanoparticles has proven to be particularly useful in the catalytic reduction of harmful dyes like Tartrazine, Carmoisine and Brilliant Blue FCF , which are prevalent in industrial wastewater and known for their toxicity and resistance to degradation. The reduction process involved a reducing agent like sodium borohydride (NaBH_4), and the presence of Au@Ag NPs significantly accelerated the reaction by facilitating electron transfer between the dye molecules and the reducing agent. This leads to rapid decolorization and breakdown of the dye into less harmful byproducts.

Overall, the green-synthesized Au@Ag core-shell nanoparticles present a promising, sustainable solution for wastewater treatment. Their high catalytic efficiency, coupled with environmentally benign production methods, positions them as valuable tools in the remediation of industrial dye pollutants.

Biography:

Dr. Bianca Moldovan obtained a PhD in Organic chemistry at Babes-Bolyai University in September 2015 and since then she is a lecturer at Chemistry Department, Faculty of Chemistry and Chemical Engineering in Cluj-Napoca Romania. Her main research focuses on natural products chemistry and synthesis of hybrid organic-inorganic nanomaterials with pharmaceutical, medical and catalytic applications.

Probing the Impact of Deposition Energy on CAE-PVD of Hard Multi-Nanolayer TiMoN/NbN Coatings

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Abstract:

Transition metal nitride coatings are essential 2-D materials that effectively protect mechanical components from rapid degradation due to their exceptional chemical inertness and hardness. Titanium nitride (TiN), a traditional nitride coating, has seen widespread use on various tools, particularly cutting implements, contributing to the “cutting tool evolution” over the past fifty years. However, conventional TiN coatings now struggle to meet the increasing demands of modern industries. There is an urgent need for advanced hard coatings that offer improved hardness and thermal stability, especially in high-speed cutting and precision applications. Significant efforts have focused on achieving these performance enhancements. One notable advancement is hard coatings featuring nanoscale multilayer architectures, which enhance hardness and thermal stability through coherent interface strengthening. Enhanced toughness is equally crucial for industrial use, as hard ceramic coatings are often prone to premature fractures due to their inherent brittleness. The nano-layer approach also introduces various toughening effects. Recently, TiMoN-based multilayer coatings have gained attention, with extensive studies on their structure and properties. This study examines how deposition energy influences the structure and properties of CAE-PVD multi-nanolayer TiMoN/NbN coatings on corrosion-resistant steel by varying the substrate bias at -100 V, -200 V, and -300 V. Additionally, the correlation between the microstructure and properties of TiMoN/NbN coatings is discussed in detail. TiMoN/NbN coatings demonstrate excellent tribological performance and, thus, show significant potential for commercial applications in the case of friction reduction and wear resistance.

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Biography:

Olga Maksakova got her PhD on Physics of Solid State in Ukraine. While studying, she was awarded an EMINENCE II scholarship and performed doctoral research at University of Porto (Portugal). Then, through a European Union countries’ recovery and resilience fund, she moved to Slovak University of Technology in Bratislava (Slovak Republic). Her main research activities focus on the development and characterization of nanostructured materials by a combination of computational and experimental approaches. She has succeeded in hard thin films based on nitrides, carbides, and borides and am fascinated by microstructural, phase, and defect investigations, as well as mechanical and tribological studies.

Reduced Graphene Oxide Aerogels as Adsorbents for Gas Phase Separations

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Abstract:

Adsorptive separations are fundamental for the science and industry. Adsorption is considered an

energy-efficient alternative for challenging separations based on distillation technology, provided that highly selective adsorbents can be engineered. Recently, reduced graphene oxide aerogels (rGOAs) have emerged as materials capable of connecting unique 2D properties of graphene/rGO with practical 3D object. They are anticipated as technology enhancing materials in different applications, including adsorption. The rGOA structure is composed of closely stacked and partially overlapping rGO flakes, that produce hierarchical pores and wrinkled texture. Surface area of rGOAs can range between tens to few hundreds $\text{m}^2 \text{g}^{-1}$, with dominant mesoporosity. Chemistry of the surface is dominated by the sp^2 carbon and high π -conjugation, with residual oxygen functional groups. Therefore, the surface can interact in different ways with adsorbates including van der Waals, electrostatic, hydrogen bonds or ion- π interactions. Our research indicate that physicochemical structure (adsorption properties as well) of rGOAs can be tailored by varying sol-gel synthesis conditions. In adsorption experiments with hexane structural isomers and saturated/unsaturated hydrocarbons, aerogels proved their potential for challenging gas-phase separations with industrial relevance, e.g. olefin-paraffin. The mechanism of separation includes both the kinetic and thermodynamic effects. The pioneering nature of our research goes beyond the current knowledge, and provide foundation for further research, both basic and applied. Moreover, it will eventually force other research areas beyond adsorption, such as catalysis, energy storage, sensors or polymer additives.

Biography:

Maksymilian Plata Gryl obtained a PhD in Chemical Sciences at Gdansk University of Technology (2022). Following a short-term research stay, in prof. Roger Gläser group, at Universität Leipzig (Germany), he was granted a research project from National Science Center (NCN, Poland). Since 2023 he is a post-doc at Gdansk University of Technology.

His research interests include the preparation and characterization of novel materials for molecular separations, especially carbonaceous sorbents for application areas such as challenging hydrocarbons separations, in gas-solid systems. Recently, he expanded his research interest by membrane-based separations.

Investigation of Embraced Metal Effects on Super Atomic Molecular Orbital of C_{70}

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Abstract:

An overlap of molecular orbital has been a research topic. This is a fundamental information to design molecular complex for designated function, including semi-conductivity, catalysis, sensor and other properties. Recently, some kinds of unoccupied molecular orbitals are widely expanded outside a molecule. the shape of molecular orbitals are similar to the atomic orbitals such as s, p, d... orbitals. The extended orbitals are called SAMO (Super Atomic Molecular Orbital). Due to the overlap of SAMOs, each molecule is expected to behave like a giant atom in the assembled structure and exhibit unique properties unlike the usual molecular solid. SAMOs are high-energy unoccupied orbitals and generally have an anisotropy, so to exploit them, the reduction of orbital energy and control or prediction of orbital direction have been desired. Herein, we calculated metal cation-embraced- C_{70} fullerene ($\text{M}^+@ \text{C}_{70}$) and

estimated the energy difference depending on the cation location, shape of SAMOs, and how the location of central metal cation affected on the orbital energy and isotropy of SAMOs. We performed DFT study for three kinds of $M@C_{70}$ ($M=Li, Na, K$). All of the optimized structures were calculated with M06/6-31++G(d,p) level and single point calculation were performed in high accuracy. In all $M@C_{70}$, the position of metal cation resulted in relatively small differences of Gibbs free energy. Small cations did not show strong effects on the shape of s-SAMO (1s atomic orbital-like SAMO), but changed the directions of p-SAMO (2px, py, or pz atomic orbital-like SAMO). Larger cation affected not only p-SAMO direction but also s-SAMO polarization and energy. Recent development of synthesis technology already enabled the distribution of $Li@C_{70}$ and other $M@C_{70}$ would be distributed in the near future. Our results form the fundamental part of the emerging SAMO-engineering.

Biography:

T.Nobeyama was given a degree of Ph.D in 2020 and had worked in Tsukuba University as a scholar of Research Fellowships for Young Scientists PD. Currently, he works as a program-specific researcher at Kyoto University, Japan. His research interest consistently focused on reaction field modulation and fundamental characteristics of reaction field components such as molecular orbital level, size and/or shape of nanomaterial and so on.

Aerobic Ethanol Oxidation by Magnetic Inductive Heating of Pd on Ni-Foam

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Abstract:

The aerobic oxidation of bio-derived ethanol to acetic acid represents a valuable alternative to conventional industrial processes. Palladium nanoparticles supported on solid substrates are effective catalysts for this transformation in aqueous media^[1]. Here, we propose a novel approach using magnetically induced heating of nickel to drive the reaction. Nickel foam was selected as a low-cost, magnetically responsive support, offering high surface area for both magnetic interaction and palladium dispersion. Two deposition strategies were employed: (i) spray-coating oxidized Ni foam with a colloidal Pd solution prepared via metal vapor synthesis^[2]; and (ii) direct electrodeposition of Pd onto bare Ni. Catalytic tests under magnetic induction heating demonstrated high acetic acid selectivity (>85%) for both catalyst types. Importantly, both systems showed excellent stability, with no significant Pd leaching into the aqueous phase. The catalytic performance was further evaluated by varying Pd loading and magnetic field strength. Recycling experiments confirmed catalyst reusability, and inductively coupled

plasma (ICP) analysis verified minimal metal loss. For comparison, both catalysts were also tested under conventional electrical heating, highlighting the advantages of magnetic induction. This study demonstrates the potential of combining magnetic materials and noble metal catalysts for efficient, sustainable chemical transformations. This work is supported by Project PRIN 2022 n. 20225RBM98, “MAGnetic Inductive heating of nano-CATalyst onto metal foam as innovative approach for selective aerobic alcohol and polyol oxidation – MAGICAT

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Biography:

Dr. Anna Maria Ferretti is a Senior Scientist at SCITEC-CNR and has led the Fantoli branch since 2019. She specializes in the synthesis and characterization of advanced nanomaterials, including magnetic oxides, polymer-based, and composite nanoparticles, for biomedical and energy applications. She is an expert in TEM, with advanced expertise in EELS, ESI, STEM, and STEM/EDX applied to inorganic, biological, and polymer nanomaterials. She has developed protocols for characterizing polymer nanostructures in organic photovoltaics and aims to design multifunctional composites that integrate inorganic nanoparticle properties with polymer-based charge transport.

The Magnetism of Hollow High-Entropy Spinel Oxide Nanofibers

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Abstract:

High-entropy oxide (HEO) nanofibers (NFs), based on equimolar (Cr,Mn,Fe,Co,Ni), (Cr,Mn,Fe,Co,Zn), and (Cr,Mn,Fe,Ni,Zn) combinations, were synthesized via electrospinning and calcination up to 900 °C.^[1] The resulting hollow NFs consist of nearly strain-free, single-crystalline spinel grains (~100 nm), with homogeneous cation distribution confirmed by EDX. Cation placement between octahedral and tetrahedral sublattices follows energetic preferences (enthalpy-driven), but within each sublattice, distribution is random (entropy-driven).

Magnetization measurements revealed a paramagnetic–ferrimagnetic (PM–FIM) transition with relatively low critical temperatures (TC): 374 K for (Cr,Mn,Fe,Co,Ni), 233 K for (Cr,Mn,Fe,Ni,Zn), and 105 K for (Cr,Mn,Fe,Co,Zn). Zn-containing NFs also exhibit a low-temperature spin-glass-like transition. Low saturation magnetization (15–40 emu/g at 5 K) indicates non-collinear FIM behavior, consistent with the proposed cation distribution. Magnetization isotherms M(H) show high coercivity (HC) for (Cr,Mn,Fe,Co,Zn) and unexpectedly low HC for (Cr,Mn,Fe,Co,Ni), attributed to different Co site occupancies. M(H) data confirms a low-T FIM phase and a high-T PM phase. No evidence of superparamagnetism or thermal activation was observed. The distinct magnetic behavior of Zn-containing NFs arises from reduced tetrahedral sublattice magnetization and weakened inter-sublattice exchange (JAB), due to Zn²⁺ in tetrahedral sites. This enhances magnetic frustration, lowering TC and spin collinearity, and promoting spin-glass-like states.

All HEO NFs show similar saturation and remanent magnetization, comparable TC, but consistently higher HC.^[2] The magnetic properties of $(\text{Cr}_{1/5}\text{Mn}_{1/5}\text{Fe}_{1/5}\text{Co}_{1/5}\text{Ni}_{1/5})_3\text{O}_4$, $(\text{Cr}_{1/5}\text{Mn}_{1/5}\text{Fe}_{1/5}\text{Co}_{1/5}\text{Zn}_{1/5})_3\text{O}_4$, and $(\text{Cr}_{1/5}\text{Mn}_{1/5}\text{Fe}_{1/5}\text{Ni}_{1/5}\text{Zn}_{1/5})_3\text{O}_4$ NFs are strongly influenced by cation distribution, enabling tunable magnetic behavior via composition control.

Acknowledgements: This work is supported by Project PRIN 2022 n. 20225RBM98, “MAGnetic Inductive heating of nano-CATalyst onto metal foam as innovative approach for selective aerobic alcohol and polyol oxidation – MAGICAT and Rendering3D - Recycling End of Life permanent magnets by innovative sintering and 3D printing. Panel: ERA-MIN3

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[2] A. Sarkar et al. doi:10.1039/D0DT04154H

Biography:

Dr. Anna Maria Ferretti is a Senior Scientist at SCITEC-CNR and has led the Fantoli branch since 2019. She specializes in the synthesis and characterization of advanced nanomaterials, including magnetic oxides, polymer-based, and composite nanoparticles, for biomedical and energy applications. She is an expert in TEM, with advanced expertise in EELS, ESI, STEM, and STEM/EDX applied to inorganic, biological, and polymer nanomaterials. She has developed protocols for characterizing polymer nanostructures in organic photovoltaics and aims to design multifunctional composites that integrate inorganic nanoparticle properties with polymer-based charge transport.

Sodium Ion Thermodiffusion in Aqueous Solutions Confined in Silica-Based Nanoporous Materials for Low-Grade Heat Conversion to Electricity

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Abstract:

Despite continuous improvements in the efficiency of existing thermoelectric generators, they remain insufficient for converting low-grade heat due to high costs, toxicity, and low efficiency. Consequently, the search for new materials and the development of technologies to capture low-grade heat are of practical importance, offering new solutions to serious environmental issues and global energy challenges caused by the ever-increasing amount of waste heat. Ionic thermoelectric devices based on aqueous electrolytes are significantly less expensive, easier to construct, and less toxic than solid-state thermoelectrics, but their energy conversion efficiency is still low. The nanoconfinement of aqueous electrolytes results in a significant enhancement in generated thermopower due to effective charge separation in nanochannels with overlapping electric double layers. Porous silica is a cheap, Earth-abundant dielectric material with low thermal conductivity and high porosity, which makes it a perfect candidate for the fabrication of a nanofluidic thermoelectric platform.

In this work, the transport and thermal diffusion of sodium ions within the aqueous electrolytes confined in a nanoporous silica matrix have been investigated. The fabricated nanofluidic platform was impregnated with aqueous solutions of sodium salts (such as Na_2SO_4 and NaCl) in concentrations ranging from 10^{-4} M to 1 M. Ion transport was studied using electrochemical impedance spectroscopy and cyclic voltammetry.

Applying a temperature difference across the nanochannels demonstrated an increase in output voltage, which is attributed to thermally induced ion transport within the silica matrix. The generated voltage generally decreases with higher concentrations of the electrolyte confined in the nanochannels, while it increases in the bulk solutions. The dependence of output voltage per Kelvin, derived from ion thermal diffusion within the i-TE platforms, varies based on electrolyte concentration and average diameter of nanochannels, and can be employed to explore the electrokinetic effects stemming from nanoconfinement.

Biography:

Irina Oliseveca is a senior researcher at the University of Latvia, Institute of Chemical Physics. Currently, her research focuses on exploring various nanostructured materials for green energy conversion and harvesting technologies.

Study of Structural, Optical and Photoelectric Properties of 3D-Printed Nanostructured CuO Films on Flexible Substrates for Environmentally Friendly Solar Cells: Effect of Thermal Annealing

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Abstract:

Nanostructured copper oxide (CuO) films were fabricated via 3D printing on flexible polyimide substrates to investigate their structural, optical, and photoelectric properties for application in environmentally friendly solar cells. CuO nanoparticles with needle-like shapes were synthesized using a polyol-colloidal method and formulated into printable inks. These films underwent thermal annealing in an argon atmosphere at different temperatures (160°C - 300°C). XRD and Raman measurements showed predominant monoclinic CuO phases, accompanied by minor cubic Cu_2O and amorphous CuO phases. Annealing at 300°C significantly improved crystalline quality, resulting in minimal microstrain. Optical studies allowed us to study the electronic properties and optical quality of the films and estimate bandgap energies, which correspond to 1.53 - 1.64 eV. The photosensitivity range extends from 0.9 to 2.5 eV, which makes them suitable for solar cell absorber layers in flexible photovoltaic devices. Studies of the structural and optical characteristics of 3D printing CuO films on flexible substrates indicate that they are promising and environmentally friendly materials for future technologies for creating efficient solar cells.

Biography:

Anatolii Bukivskii, PhD, is a Lead Researcher at the Institute of Physics, National Academy of Sciences of Ukraine. He obtained his MSc degree in Physics (2014) from Taras Shevchenko National University of Kyiv and his PhD (2018) specializing in semiconductor physics. Anatolii has participated in numerous

scientific projects funded by the National Research Foundation of Ukraine and NATO's Science for Peace and Security Programme. His research interests include electronic and structural properties of semiconductor materials.

Plasma-Oxidation Driven Surface Instability in PDMS: Mechanisms and Morphological Evolution

Sushree Ritu Ritanjali*, and Rabibrata Mukherjee

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Abstract:

The fabrication of controlled surface topographies on soft polymer substrates has gained significant attention due to its potential applications in microfluidics, optics, sensors, and flexible electronics. In this work, we present a systematic study on the formation of plasma-induced wrinkle morphologies on uncross-linked polydimethylsiloxane (PDMS) thin films. Oxygen plasma treatment is employed to generate a mechanically heterogeneous bilayer system, where a thin, stiff silica-like (SiO_x) film forms atop a compliant PDMS substrate. This oxidation-induced mismatch in mechanical properties results in a compressive stress build-up during the cooling phase, leading to spontaneous formation of wrinkle patterns via buckling instability.

The wrinkling process was monitored using optical microscopy and characterized by atomic force microscopy (AFM), confirming the formation of periodic undulations across the surface. We observed that the wrinkle wavelength and amplitude are strongly dependent on the plasma exposure duration and power. Prolonged plasma treatment leads to an increase in both the thickness of the oxidized layer and the mechanical contrast with the underlying PDMS, thereby tuning the wrinkle periodicity. Additionally, post-treatment thermal annealing and repeated short-duration plasma exposures were explored as strategies for further modulation of the wrinkle dimensions. These secondary processes were found to enhance compressive strain and reduce wavelength, providing additional control over surface patterning.

This method provides a metal-free, scalable approach to tailor surface features on elastomeric substrates without the need for complex lithographic techniques. The ability to tune nanoscale topographies by adjusting simple process parameters opens avenues for the design of functional surfaces with controlled wettability, adhesion, and optical properties. The results of this study offer insights into the mechanical behavior of plasma-oxidized PDMS films and demonstrate a reliable framework for engineering soft material interfaces for emerging technologies.

Biography:

Sushree Ritu Ritanjali is a doctoral research scholar in the Department of Chemical Engineering at IIT Kharagpur. Her research is centered on the fundamental physics of soft materials, particularly polymer thin films, surface instabilities, and wrinkling phenomena. She investigates the mechanisms of dewetting, plasma-induced surface patterning, and morphological evolution in elastomeric systems like PDMS. Her work contributes to a deeper understanding of interfacial phenomena, thin film dynamics, and self-organized pattern formation. She has presented her findings at various national and international conferences and is dedicated to advancing knowledge in the field of soft matter physics.

Computational Evaluation of Copolymer Synthesizability for New Materials for Environmental Sustainability

Sidh Jaddu

Thomas Jefferson High School for Science and Technology, Alexandria, VA, United States

Abstract:

The need for novel and advanced materials has never been greater, especially in advanced battery technologies, or biodegradable plastics. Researchers have been applying various methodologies to identify new materials with different properties that cater to their needs, and leveraging machine learning to identify these materials has become a popular approach. Copolymers offer a good option for many such applications which require materials with desired characteristics. While there have been computational approaches (e.g., Matmerize) to predict properties of newly conceived copolymers, there haven't been any computational tools to evaluate whether a copolymer is synthesizable. Tools such as SA Score help with determining synthesizability of homopolymers but do not apply to copolymers. The lack of synthesizability evaluation tools for copolymers limits the discovery of new materials. This research was conducted to fill this gap and create a computational approach that evaluates copolymer synthesizability.

To evaluate copolymer synthesizability, a synthesizability model was created by fine-tuning a ChemBERTa transformer with copolymer training data. Copolymer training data included PSMILES sequences of 2,150 known, synthesizable linear copolymers (random, block, and alternate) from sources such as PolyInfo and an additional 40,830 PSMILES of empirically synthesizable linear copolymers created using augmentation techniques. The fine-tuning was performed using masked language modeling with a custom loss function, allowing the model to provide synthesizability scores for newly conceptualized linear copolymers. The synthesizability transformer achieved a synthesizability accuracy of 92%. Using the transformer, 1.84 million biodegradable copolymer candidates were successfully analyzed, and 40 synthesizable, biodegradable copolymers were identified as plastic alternatives.

The research confirmed that synthesizability evaluation for copolymers can be performed computationally using AI, which helps reduce the time and costs of discovering new materials for environmental sustainability. Future work includes leveraging BigSMILES, ensuring that more aspects of copolymers can be considered in synthesizability assessment.

Biography:

Sidh Jaddu is a rising junior at Thomas Jefferson High School for Science and Technology, passionate about making advancements in materials science to solve challenging problems, especially in energy and environmental sustainability. He recently researched and identified the unmet need for computational evaluation of copolymer synthesizability. To address this, he built a deep-learning framework that successfully analyzed 1.84 million biodegradable copolymer candidates and identified 40 synthesizable, biodegradable copolymers as plastic alternatives. Although this framework was designed for biodegradable plastics, the framework can easily be customized and used in other energy and environmental applications including advanced battery technologies.