

Abstract Book

6th
INTERNATIONAL CONFERENCE ON
**MATERIALS SCIENCE &
NANOTECHNOLOGY**

Future Materials 2025

TENERIFE, SPAIN | OCTOBER 27-29, 2025

ONLINE, ZOOM | OCTOBER 30, 2025



Plenary Talks

Chemical Patterning of Graphene and Inorganic 2D-Materials

Andreas Hirsch*

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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

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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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²Opportunius. 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

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

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.

Acknowledgement: 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 ranges 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*, **María Medel***, **Esther Martínez**, **Amina Benaicha**, **Snežana Đorđević**, and **Inmaculada Conejos-Sanchez**

Príncipe Felipe Research Center. Polymer Therapeutics Laboratory and CIBERONC Eduardo Primo Yúfera, 3, 46012 Valencia, Spain

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 **María I. Moreno^{1,2}**

¹Innovative Macromolecular Materials (IMACROMAT), Physical Chemistry Department, Faculty of Science and Technology, Universidad del País Vasco UPV/EHU, 48940 Leioa, Spain

²BCMaterials, 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*

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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

Nanotechnology and Regenerative Medicine Commercialization Centre (NanoRegMed Ltd, Nanoloom Ltd, & Liberum Health Ltd), The London BioScience Innovation Centre, United Kingdom

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

Photoactive Nanostructured Coordination Polymers as Novel Materials for Cancer Therapy

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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 or 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:

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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 adjuvant 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), 12997-1300

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^{*1,2,3,4}, Patricia Díaz-Saldívar⁵, Ingrid Araya⁶, Freddy Celis⁷, Diego Cortés-Arriagada⁸, Ana Riveros^{3,4}, Carlos Rojas-Romo¹, Carolina Jullian⁹, Nataly Silva⁴, Nicolás Yutronic¹, Marcelo J. Kogan^{3,4}, and Paul Jara¹

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⁷*Laboratorio de Procesos Fotónicos y Electroquímicos, Facultad de Ciencias Naturales y Exactas, Universidad de Playa Ancha, Valparaíso 2360002, Chile*

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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 University of Desarrollo. 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 Zavier 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. She 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 Barrueta

GAIKER Technology Centre, Basque Research and Technology Alliance (BRTA), 48170 Zamudio, Spain

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

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

²University 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

Department of Molecular Sciences and Nanosystems Ca' Foscari University of Venice Venezia, 30170, Italy

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.

References:

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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 work 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 Nanoplatfoms 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 nanoplatfoms 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 nanoplatfoms. Through molecular engineering strategies on different biomaterials, we have successfully prepared multifunctional molecular targeted nanoplatfoms 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 ($< 300 \text{ mT}$) 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.