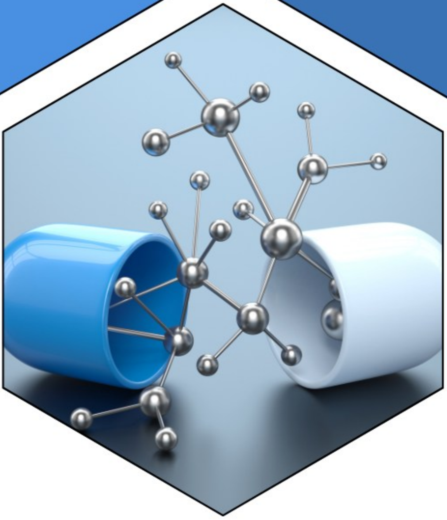

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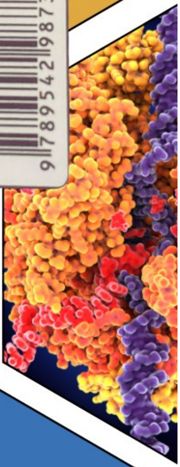

INTERNATIONAL CONFERENCE ON FUNCTIONAL NANOMATERIALS AND NANODEVICES

NANOMAT2025

2-5 September 2025 | Zagreb, Croatia

ENNA
Organized by
European Nanoscience and
Nanotechnology Association

www.nanomat-conference.com

International Conference on Functional Nanomaterials and Nanodevices

2-5 September 2025 | Zagreb, Croatia

ABSTRACT BOOKLET

Conference Venue:

The Westin Zagreb **** (conference venue)
Address: Kršnjavoga 1, Lower Town, 10000 Zagreb, Croatia

Editors: Saim Emin
Dominik Eder
Alla Zak
Pawel Kulesza
Polina Mladenova

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Welcome Message

Dear Colleagues,

It is with great pleasure that we welcome you to the **9th edition of the International Conference on Functional Nanomaterials and Nanodevices – NANOMAT2025**, taking place from **September 2–5, 2025**, at **The Westin Zagreb Hotel, Zagreb, Croatia**.

This annual event serves as a dynamic platform for researchers, scholars, and professionals from around the globe to exchange cutting-edge insights and foster meaningful collaborations in the rapidly evolving field of nanotechnology.

Over the coming days, we will delve into a wide array of topics encompassing the latest advancements in **nanomaterials, nanoelectronics, nanomedicine**, and other interdisciplinary applications. Our scientific program includes an exceptional lineup of **plenary, invited, oral, and poster presentations**, each offering valuable perspectives and breakthroughs from academia and industry alike.

The abstracts presented in this book reflect the dedication, innovation, and collaborative spirit of our contributing authors. Each submission has been thoroughly reviewed to ensure that the highest standards of scientific quality are maintained. We are confident that the knowledge shared throughout this conference will ignite new ideas and partnerships that will shape the future of nanoscience and nanotechnology.

Organizing a conference of this scale is a collective achievement. We extend our heartfelt thanks to all participants, speakers, session chairs, reviewers, and supporters whose efforts have made NANOMAT2025 possible.

We hope you find the event both intellectually rewarding and personally enriching. Take full advantage of the networking opportunities, engage in thoughtful discussions, and enjoy your time in the beautiful city of Zagreb.

Thank you for being part of **NANOMAT2025**. We look forward to a memorable and impactful conference.

Sincerely Yours,

Organizing Committee
Prof. D. Eder, *Technical University of Vienna (TU Wien), Austria*
Prof. P. Kulesza, *University of Warsaw, Poland*
Prof. A. Zak, *Holon Institute of Technology, Israel*
Prof. S. Emin, *University of Nova Gorica, Slovenia & European Nanoscience and Nanotechnology Association, Bulgaria*

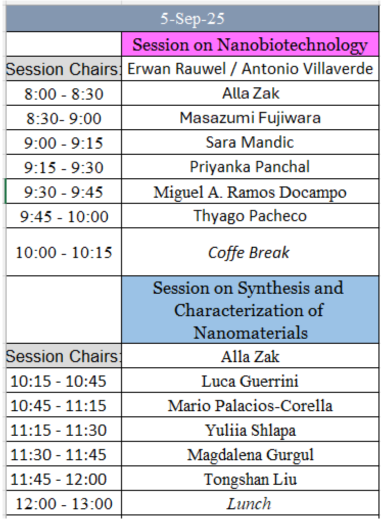
Program September 3, 2025

2-Sep-25					
18:00 - 20:00	Registration & Simple reception				
3-Sep-25					
07:30 -18:30	Registration				
08:30 - 08:40	Conference Opening *(Crystall Ballroom B hall)*				
08:40 - 09:30	Plenary Speaker - **Yoshihiro Iwasa** *(Crystall Ballroom B hall)*				
09:30 - 10:20	Plenary Speaker - **Shelley Minteer** *(Crystall Ballroom B hall)*				
10:20 - 10:30	Group Photo				
10:30- 11:00	*Coffe Break*				
	Session on Catalysis for Clean Energy and Chemical Production *(Maksimir hall)*		Session on Synthesis and Characterization of Nanomaterials *(Crystall Ballroom B hall)*		Session on Nanobiotechnology
Session Chairs:	Maya Bar Sadan	Session Chairs:	Maria Lucia Curri / Dirk Kuckling	Session Chairs:	Erik Reimhult / Jurriaan Huskens
11:00 - 11:30	Pawel Kulesza	11:00 - 11:30	Krzysztof Pielichowski	11:00 - 11:40	Naoki Komatsu
11:30 - 12:00	Ioan-Cezar MARCU	11:30 - 12:00	Vincenzo Guidi	11:40 - 12:10	Larysa Baraban
12:00 - 12:30	Nejc Hodnik	12:00 - 12:30	Rasa Pauliukaite	12:10 - 12:25	Alexandre Adam
12:30 - 13:30	*Lunch*				
			Session on Synthesis and Characterization of Nanomaterials *(Crystall Ballroom B hall)*		Session on Energy Conversion and Storage Materials
		Session Chairs:	Vincenzo Guidi / Rasa Pauliukaite	Session Chairs:	Iwona A. Rutkowska / Rafael Muñoz-Espi
		13:30 - 14:00	Protima Rauwel	13:30 - 14:00	Adalgisa Sinicropi
		14:00 - 14:30	Maria Lucia Curri	14:00 - 14:30	Andrea Reale
		14:30 - 15:00	Lenka Zajickova	14:30 - 15:00	Ivan Khalakhan
		15:00 - 15:30	Dirk Kuckling	15:00 - 15:15	Aleksandra Tomaszowska
15:30 - 16:00	*Coffe Break*				
	Session on Catalysis for Clean Energy and Chemical Production *(Maksimir hall)*		Session on Synthesis and Characterization of Nanomaterials *(Crystall Ballroom B hall)*		Session on Nanobiotechnology
Session Chairs:	Ioan-Cezar MARCU / Nejc Hodnik	Session Chairs:		Session Chairs:	Esther Vázquez Gómez
16:00 - 16:30	Dominik Eder	16:00 - 16:15	Vasyl Shvalya	16:00 - 16:30	Jurriaan Huskens
16:30 - 17:00	Frank Marken	16:15 - 16:30	Julien Mahin	16:30 - 17:00	Nermin Seda Kehr
17:00 - 17:15	Alberto Llopis-Lacruz	16:30- 16:45	Sakineh Akbari Nia	17:00 - 17:30	Erik Reimhult
17:15 - 17:30	Pavel Topka	16:45 - 17:00	Alejandra Durán Balsa	17:30 - 18:10	Ernst Wagner
17:30 - 17:45	Kimia Jafari	17:00 - 17:15	Ali Kemal Ateş		

Program September 4, 2025

4-Sep-25					
07:45 -18:30	Registration				
08:40 - 09:30	Plenary Speaker - **Ulrich Wiesner** (Crystall Ballroom B hall)				
09:30 - 10:20	Plenary Speaker - **Reshef Tenne** (Crystall Ballroom B hall)				
10:30- 11:00	Coffe Break				
	Session on Energy Conversion and Storage Materials (Maksimir hall)		Session on Synthesis and Characterization of Nanomaterials (Crystall Ballroom B)		POSTER SESSION - ALL DAY
Session Chairs:	Adalgisa Sinicropi / Ivan Khalakhan	Session Chairs:	Klara Hernadi / Vojtech Uhlir		
11:00 - 11:30	Iwona A. Rutkowska	11:00 - 11:30	Jozef Keckes		
11:30 - 12:00	Andrea Lamberti	11:30 - 12:00	Marco Anni		
12:00 - 12:30	Rafael Muñoz-Espi	12:00 - 12:15	Glemarie Hermosa		
		12:15 - 12:30	Emma Cenac-Morthe		
12:30 - 13:30	Lunch				
	Session on Nanobiotechnology (Maksimir hall)		Session on Synthesis and Characterization of Nanomaterials (Crystall Ballroom B)		POSTER SESSION - ALL DAY
Session Chairs:	Masazumi Fujiwara / Nermin Seda Kehr	Session Chairs:	Ivana Vinković Vrček		
13:30 - 14:00	Salvador Pane Vidal	13:30 - 14:00	Ladislav Kavan		
14:00 - 14:30	Esther Vázquez Gómez	14:00 - 14:30	Klara Hernadi		
14:30 - 15:00	Antonio Villaverde	14:30 - 15:00	Vojtech Uhlir		
15:00 - 15:30	Erwan Rauwel	15:00 - 15:15	Jia Wang		
		15:15 - 15:30	Angelika Mieszczanin		
15:30 - 16:00	Coffe Break				
	Session on Catalysis for Clean Energy and Chemical Production (Maksimir hall)		Session on Synthesis and Characterization of Nanomaterials (Crystall Ballroom B)		POSTER SESSION - ALL DAY
Session Chairs:		Session Chairs:	Ladislav Kavan / Lenka Zajickova		
16:00 -16:30	Janis Timoshenko	16:00 - 16:30	Josep Puigmarti-Luis		
16:30 - 17:00	Maya Bar Sadan	16:30 - 17:00	Ivana Vinković Vrček		
17:00 - 17:15	Isabell Wachta	17:00 - 17:15	Anna Pajor-Swierzy		
17:15 - 17:30	Robert Jungnickel	17:15 - 17:30	Tânia Grainha		
17:30 - 18:30	Poster Session				
18:30 - 21:00	Conference Dinner				

Program September 5, 2025



5-Sep-25	
	Session on Nanobiotechnology
Session Chairs:	Erwan Rauwel / Antonio Villaverde
8:00 - 8:30	Alla Zak
8:30- 9:00	Masazumi Fujiwara
9:00 - 9:15	Sara Mandic
9:15 - 9:30	Priyanka Panchal
9:30 - 9:45	Miguel A. Ramos Docampo
9:45 - 10:00	Thyago Pacheco
10:00 - 10:15	*Coffe Break*
	Session on Synthesis and Characterization of Nanomaterials
Session Chairs:	Alla Zak
10:15 - 10:45	Luca Guerrini
10:45 - 11:15	Mario Palacios-Corella
11:15 - 11:30	Yuliia Shlapa
11:30 - 11:45	Magdalena Gurgul
11:45 - 12:00	Tongshan Liu
12:00 - 13:00	*Lunch*

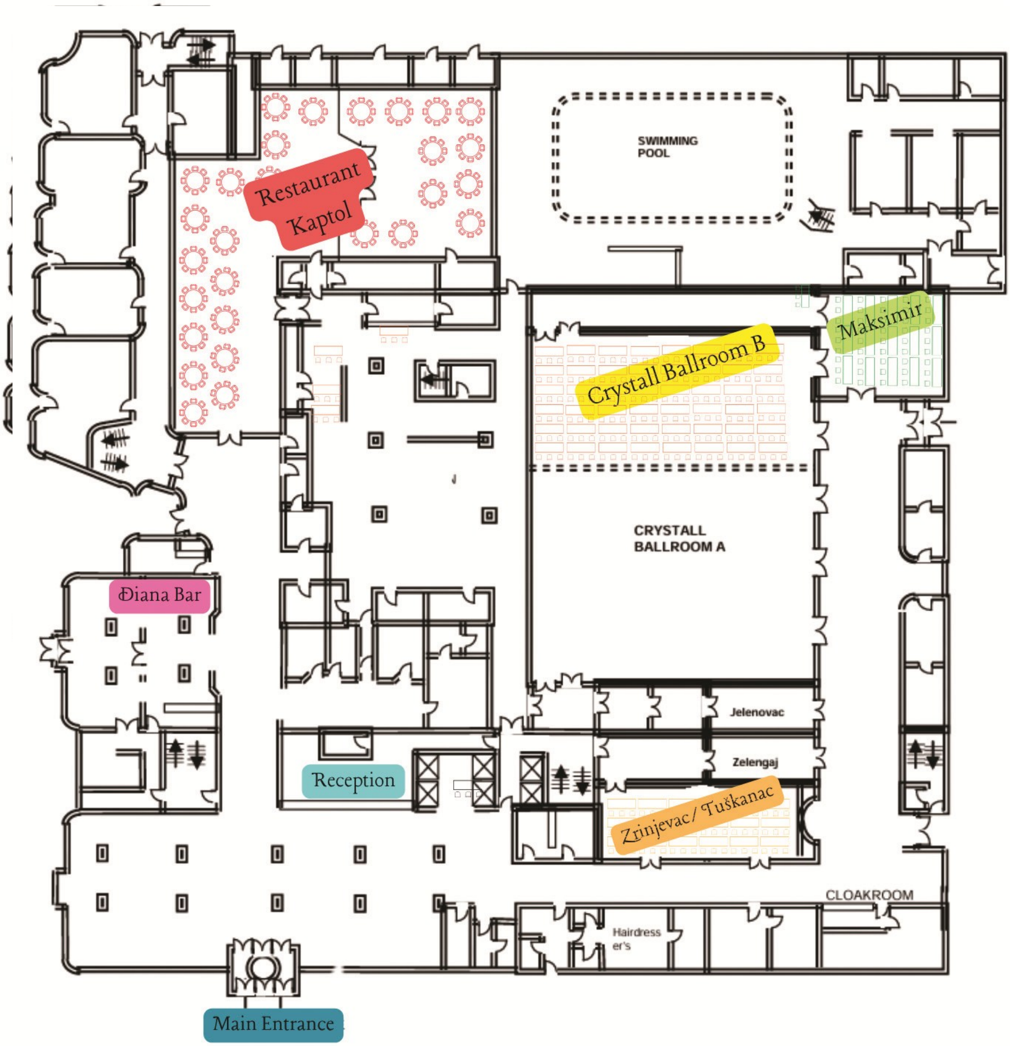
Poster Session

Presenter Name	Title
Ashok Rao	*Investigation on thermoelectric properties of In-doped n-type Bi1.5Sb0.5Te3 alloy*
Sudhakar Y N	*Unlocking Potential: Iodide-Doped Nickel-Boosted MXene Composite for High-Performance Sodium-Ion Hybrid Capacitors*
Jung Kyoo Lee	*A Scale-up Synthesis of Porous Silicon Particles: Reduction Conditions versus Properties on the Li-Battery Anode Performances*
Do Hwan Kim	*Phosphorus-Doped Ni–Co/Graphene Electrocatalysts for Bifunctional Energy Conversion: A Combined Experimental and Theoretical Study*
Santosh L. Gaonkar	*Design, Spectral Characterization, and Photophysical Analysis of a Hydroxy-Substituted Chalcone Derivative*
Bartłomiej Orczykowski	*Morphology Controlled Low-Temperature CVD Synthesis of SnO2 Nanocones for Photoelectrochemical Applications*
Dhanya Sunil	*Nanophosphor incorporated metal alloy for anticounterfeit application*
Preethi Kumari P	*Biopolymer nanocomposite as a potential corrosion inhibitor for mild steel in acid medium*
Suma A Rao	*Eco-Friendly Inhibitor for Corrosion Protection of 6061 Al Alloy in Acidic Environments*
Poornima Bhagavath	*Mesomorphic study of nanocomposites of liquid crystals*
Aleksandra Swierkular	*Changing hydrodynamic conditions to obtain AAO layers with complex channel geometry*

Presenter Name	Title
Vítek Hrbacek	*Selectively Oxidized Schizophyllan as a Template for the Synthesis of Gold Kite-like Nanostructures*
Tae-hyun Nam	*Role of nano-domain and omega phase on the superelasticity of Ti-Zr-Nb-Sn alloys for biomedical applications*
Karolina Kukrálová	*Engineering Composite Fe3O4-MOF for Sensing and Removal of Diclofenac*
Karolina Mertin	*Impact of Degradation Factors on the Properties of Conductive Polymers*
Ivana Jelovica Badovinac	*Synthesis and characterization of photocatalytic TiO2/Cu composite thin films*
Kang-San Lee	*Effect of ethylene oxide-based ion-conducting plasticizers on the properties of lithium-ion conducting electrolyte membranes*
Jeongyun Seo	*Fabrication and Characterization of Polymer Electrolyte Membranes Incorporating Ion-Conductive Copolymers*
Dominika Bury	*MoB and Mo2B2 MBenes for Enhanced Photocatalytic Decomposition of Organic Pollutants*
Chulwoong Han	*Synthesis of Nickel Nanoparticles Encapsulated with Carbon via Reactive Inductively Coupled Thermal Plasma*
Gisya Abdi	*Effect of organic cations on optical and electrical properties of bismuth iodide complexes in memristive devices*
Elena Miliutina	*Preparation and Optical Characterization of Plasmonic Pd/Au Nanostructures for Hydrogen-Sensitive Using Fiber-Optic Interfaces*
Anastasiia Tulupova	*Spin-Selective Chemistry in the Presence of Chiral Plasmonic Fields*
Vasilii Burtsev	*Plasmonic Field Engineering in Au–Polymer–Pt Nanoarchitectures for Enhanced Photocatalytic Hydrogen Production*
Gloria Alexander	*Bilayer Nitrogen-Doped Graphene Electrodes: Minimizing Substrate Effects for Improved Electrochemical Properties*
Nitinkumar S. Shetty	*L-proline catalyzed multicomponent synthesis of pyrano-pyrimidines*
Ahmed Balah Tahir	*Gold Nanoparticles and Immobilized Laccase: A Synergistic Approach for Green Catalysis*
Michał Jakubczak	*Light-activated antibacterial performance of a novel MoAlB@MBene core-shell nanostructure*
Raúl Martínez-Baquero	*Nanostructured Fluorescent Eutectogels: A Versatile Platform for Bioanalytical Applications*
Kontad Ounnunkad	*Electrochemical Bioplatform Based on a Gold Nanoparticles/Graphene Oxide/MoO3-MoS2 Nanocomposite and Hydroquinone/Gold Nanotags for the Competitive Detection of Cyfra 21-1*
Andrea Cruz	*Apoptosis Biosensor: Evaluating Drug Impact On Pregnancy*
Andrea Cruz	*Electrochemical Biosensors for the Detection of CCL3 and TGF-β1 as Biomarkers in Inflammatory Disease Screening*
Carla M. Carvalho	*Biosensing Approach for Biomarker Detection in Infectious Diseases*

The Poster Session will take place in Hall Zrinjevac/Tuškanac.
All participants are kindly requested to mount their posters by **10:30 AM** on the day of the session.

Floorplan NANOMAT2025 - The Westin Zagreb Hotel



Plenary Speakers

Ulrich Wiesner

Cornell University, Ithaca, USA

*Title: "**Nanostructured functional materials and their applications**"*

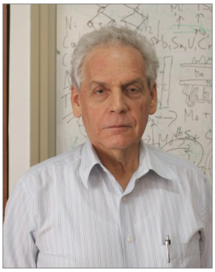
Ulrich (Uli) Wiesner studied Chemistry at the University of Mainz, Germany, and UC Irvine, CA. He gained his Ph.D. in 1991 in Physical Chemistry with work at the Max-Planck-Institute for Polymer Research (MPI-P), Mainz, on holographic information storage in polymer liquid crystals. After a two-year postdoc at E.S.P.C.I. in Paris, France, on local dynamics-mechanical property correlations in polyesters, he returned to the MPI-P in 1993. In 1998 he finished his Habilitation with work on block copolymers under oscillatory shear and block copolymer ionomers and received tenure as an MPI-P staff member. He joined the Cornell University, NY, Materials Science and Engineering (MSE) faculty in 1999 as a tenured Associate Professor, became a Full Professor in 2005, and since 2008 is the Spencer T. Olin Professor of Engineering. At Cornell, he holds secondary appointments (field membership) in Chemical and Biomolecular Engineering (CBE), Biomedical Engineering (BME), and Chemistry and Chemical Biology (CCB). Since January of 2023 he is an inaugural faculty member of the multi-college Department of Design Tech at Cornell and Professor of Design Tech. Since his arrival at Cornell, he has worked at the interface between polymer science and inorganic/solid-state chemistry with the goal to generate multifunctional nanomaterials for applications including energy conversion and storage, clean water, and nanomedicine. From 2015-2021 he was the co-director of the MSKCC-Cornell Center for Translation of Cancer Nanomedicine (MC2TCN), one of six Centers for Cancer Nanotechnology Excellence (CCNE) funded by the NCI.

Yoshihiro Iwasa

Deputy Director, RIKEN Center for Emergent Matter Science, Saitama, Japan

Title: ***"Symmetry and nonlinear responses in nanomaterials"***

Yoshihiro Iwasa earned his Ph.D. in 1986 from The University of Tokyo, where he later held positions as a research associate and then a lecturer. In 1993-1994, he was a visiting scientist at AT&T Bell Laboratories in Murray Hill, USA. In 1994, Iwasa transitioned to associate professor at the Japan Advanced Institute of Science and Technology (JAIST), before ascending to the position of full professor at the Institute for Materials Research, Tohoku University in 2001. In 2010, he made the move to the Department of Applied Physics at The University of Tokyo, concurrently taking on the role of team leader at the RIKEN Center for Emergent Matter Science. His research expertise lies in the realm of nanomaterial physics, with a specific focus on 2D materials. Iwasa's work centers on field effect control of the quantum phase of matter through innovative device designs. Throughout his illustrious career, he has garnered several awards, including the Japan IBM Science Prize, The Commendation for Science and Technology by the Minister of MEXT, the Honda Frontier Prize, and the Nishina Memorial Prize.



Reshef Tenne

Weizmann Institute of Science, Rehovot, Israel

Title: ***"Inorganic nanotubes- synthesis, properties and applications"***

Reshef Tenne was born in 1944 in Kibbutz Usha. He earned his Ph.D. in 1976 in the Hebrew University. He joined the Weizmann Institute in 1979, where he was promoted to a professor in 1995. In 1992 he discovered a new family of nanomaterials- the so-called inorganic nanotubes and fullerene-like (IF) nanoparticles from layered compounds (2D materials). He and his research group synthesized and studied many kinds of inorganic nanotubes. He received numerous prizes including lately the ACS Chemistry of Materials award (2023) and the Von Hippel award of the MRS (2023)- the highest recognition of this society. He is a Fellow of several organizations and a member of the Israeli Academy of Sciences and Humanities; Academia Europaea and the European Academy of Arts and Sciences.

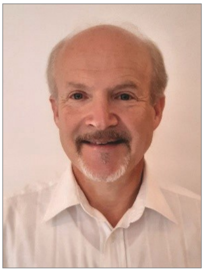
Shelley Minteer

University of Utah, United States

Title: ***"Bioelectrocatalysis for Electrosynthesis"***

Dr. Shelley Minteer is a Professor of Chemistry and the Director of the Kummer Institute Center for Resource Sustainability at Missouri University of Science and Technology. She is also the Director of the NSF Center for Synthetic Organic Electrochemistry. She received her PhD in Analytical Chemistry at the University of Iowa in 2000 under the direction of Professor Johna Leddy. After receiving her PhD, she spent 11 years as a faculty in the Department of Chemistry at Saint Louis University before moving to the University of Utah in 2011 to lead the USTAR Alternative Energy Cluster. She was a Technical Editor for the Journal of the Electrochemical Society (2013-2016) and also an Associate Editor for the Journal of the American Chemical Society (2016-2020) before becoming the inaugural Editor-in-Chief of the ACS Au Journals. She has published greater than 450 publications and greater than 550 presentations at national and international conferences and universities. She has won several awards including the Luigi Galvani Prize of the Bioelectrochemical Society, International Society of Electrochemistry Tajima Prize and Bioelectrochemistry Prize, Grahame Award of the Electrochemical Society, Fellow of the Electrochemical Society and the International Society of Electrochemistry, American Chemical Society Division of Analytical Chemistry Award in Electrochemistry, and the Society of Electroanalytical Chemists' Young Investigator Award and Reilley Award. Her research interests are focused on electrocatalysis and bioanalytical electrochemistry for biosensors, biofuel cells, electrosynthesis, and bioelectronics.

Keynote Speakers

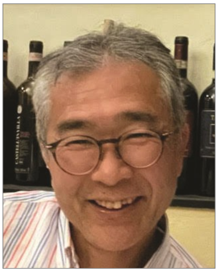


Ernst Wagner

Ludwig-Maximilians University of Munich, Munich, Germany

Title: ***"Genome Editing and RNA Delivery by Chemical Evolution"***

Prof. Ernst Wagner is Chair of Pharmaceutical Biotechnology, Department of Pharmacy at LMU Munich since 2001. After PhD in chemistry (1985, TU Vienna, Austria) he was postdoc at ETH Zurich (1985-1987), working on origin-of-life chemistry of nucleic acids, Group Leader at IMP Vienna (1988-1995) exploring receptor-mediated gene delivery, Director for Cancer Vaccines (1992-2001) at Boehringer Ingelheim Austria, preparing the world-wide first polymer-based gene therapy trial in 1994. In 1996 he was Professor for Biopharmaceutical Sciences, Utrecht University. Ernst is Academician of European Academy of Sciences, member of College of Fellows of Controlled Release Society (CRS), Guest Professor at Fudan University (2012), Honorary Professor at Sichuan University (2018) and Jinan University (2021), Board Member of German Society for Gene Therapy and Nonviral Therapeutic Delivery Committee, America Society of Gene and Cell Therapy (ASGCT). He authored 523 publications, >54 500 citations, h-index 116 (GS).



Naoki Komatsu

Kyoto University, Japan

Title: ***"RadioNano Therapeutics" for Cancer by Functionally Programmed Medical Nanodevices"***

Prof. Komatsu received his bachelor's, master's and doctor's degrees from Kyoto University in 1986, 1988 and 1993, respectively. He joined Okayama University in 1993 and moved to Kyoto University as Assistant Professor in 1994. In 1997, he worked at Florida State University as a visiting scholar for one year. In 2003, he moved from Kyoto University to Shiga University of Medical Science as Associate Professor. He was promoted to full Professor at Kyoto University in 2015. He is one of the cofounders of the startup "RadioNano Therapeutics Inc." which was established in Apr. 2024, based on the novel "RadioNano" sensitizer in boron neutron capture therapy (BNCT) for cancer. His research concept is to "apply organic chemistry to nanomaterials" including supramolecular chemistry for structural separation of nanocarbons and synthetic organic chemistry on inorganic nanoparticles for cancer nanomedicine.

Invited Speakers

Adalgisa Sinicropi

University of Siena, Siena, Italy

Title: ***"Design of organic and bio-inspired materials for the development of solar energy conversion devices"***

Prof. Adalgisa Sinicropi (Female), FRSC, Associate Professor at the University of Siena, President of the Administrative Board and Co-founder of the Spin-off LifeC-ARES srl, Renewable Energy and Sustainability, (www.lifecares.unisi.it) and group leader of the R2ES Lab (www.r2eslab.com). She is a specialist in computational chemistry and her recognized research activity comprises the design and characterization by computational methods and life cycle analysis of innovative materials to produce new-generation photovoltaics characterized by high efficiency, stability, and high environmental added value. More specifically, she acquired a robust experience researching structural patterns to impart specific optical characteristics to chromophores to optimize solar cell properties and the life cycle environmental impact analysis of materials and their reuse/recycling potential.

Andrea Reale

University of Rome Tor Vergata, Italy

Title: ***"Printable thermoelectric materials: from cell to modules"***

Research activity of Prof. Reale (H=40, Google Scholar) is focussed on 1) Printable electronics for energy: development and characterization of devices based on organic semiconductors and organic-inorganic hybrids, with particular attention to the technological aspects of large-area scale-up for applications in the energy field (photovoltaic, thermoelectric, termoelectrogalvanic) and telecommunication devices (photodetectors for VLC and IR, IR sources); 2) Nanostructured materials (graphene, carbon nanotubes): study of technological applications (thermoelectric composites, thermal management, deformation sensors); 3) Theoretical and experimental analysis of the optical, electro-optical and electrical properties of heterostructure devices for electronics and telecommunications.

Andrea Lamberti

Polytechnic University of Turin, Italy

Title: ***"Emerging energy harvesting from X-gradient: the case of low grade waste heat, CO2 and salinity gradient"***

Andrea Lamberti is Full Professor of Experimental Physics of Matter at the Applied Science and Technology Department of 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 microfluidics, plasmonics, nanostructured materials and electrochemical energy devices (photovoltaics and supercapacitors and their integration) which have led to numerous European and national projects (MISE, MITE, MASE, H2020 and an ERC starting grant) and patents. Actually, he is the coordinator of the PhD NATIONAL program in Materials, Sustainable Processes and Systems for the Energy Transition, deputy-coordinator of the Bachelor degree in Physical Engineering at PoliTO and member of the board of the Italian Association of Science and Technology.

Antonio Villaverde

Autonomous University of Barcelona, Spain

Title: ***"Artificial amyloids as implantable depots for the slow delivery of protein nanoparticles and therapeutic proteins"***

A. Villaverde is Chair Professor of Microbiology at the Department of Genetics and Microbiology and leader of the Nanobiotechnology group at the Institute for Biotechnology and Biomedicine, Autonomous University of Barcelona. He coordinates a research team of about 20 people that is member of the Networking Biomedical Research Center in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN). He also leads the Innovative Biodrugs Team of the Catalan autonomous government. Prof. Villaverde has authored more than 340 peer-reviewed research and review papers on microbiology-biotechnology-nanosciences, apart from several books, book chapters, patents and more than 330 communications to congresses. A. Villaverde founded the Open-Access journal Microbial Cell Factories, of which he has been Editor-in-Chief from 2002 to 2016.

Dirk Kuckling

Paderborn University, Paderborn, Germany

Title: ***"Stimuli-degradable Polymer Particles for Triggered Drug Release"***

Prof. Dr. Dirk Kuckling is the Head of the Institute and holds the W3 Professorship for Organic and Macromolecular Chemistry at Paderborn University, Germany.
He earned his Ph.D. in Organic Chemistry from Christian-Albrechts-Universität zu Kiel in 1994, with a dissertation focused on the stereoselective synthesis of Bi[10] paracyclophanes and enantiomerically pure trisubstituted tetrahydrofurans. Following postdoctoral research at the Technical University of Dresden, he completed his habilitation in Macromolecular Chemistry in 2004, presenting work on smart hydrogels. Prof. Kuckling has held visiting positions at Stanford University and was appointed to his current role at Paderborn University in March 2008. His research interests include the development of novel polymers from renewable resources and the creation of (bio-)degradable polymers with enhanced properties.
In recognition of his contributions, he was awarded an honorary professorship at Jiangsu University in Zhenjiang, China, in October 2019.

Erik Reimhult

BOKU University, Vienna, Austria

Title: ***"Studying bacteria and their interactions with holographic microscopy"***

E. Reimhult obtained his PhD in 2004 from Chalmers University of Technology, which was followed by postdocs at IMRE in Singapore and ETH Zürich. From 2008, he was a Senior scientist in the Laboratory for Surface Science and Technology at ETH Zürich, supervising a group working on lipid membranes, nanoparticles, and biosensors. Since 2010, he has been a Professor of Nanobiotechnology at BOKU University and head of the Institute of Colloid and Biointerface Science. He was awarded the ERC Consolidator Grant in 2012, followed by an ERC PoC grant, and was elected to the Young Academy of the Austrian Academy of Sciences in 2013. His research is currently focused on using colloidal methods to study the interactions of bacteria and biofilms with solid and liquid interfaces, fabricating functional bionanocomposites, and synthesizing responsive polymer nanostructures with applications in biotechnology and medicine. While primarily focusing on fundamental research in these areas, his research has led to numerous patents and three spin-offs.

Erwan Rauwel

Estonian University of Life Sciences, Tartu, Estonia

Title ***"Assessing Cobalt Nanoparticles and Nanocomposites for Biomedical Applications and Water Remediation"***

Erwan Rauwel received his PhD degree from University of Caen in Materials Science in 2003. He continued with postdoctoral studies in collaboration with STMicroelectronics at Minatec, Grenoble, France, and at the University of Aveiro (Marie Curie IE Fellowship), Portugal. He worked for 3 years as Senior Researcher at University of Oslo in collaboration with Statoil and then joined Taltech as Professor in Estonia for 5 years. He is now Professor at the Estonian University of Life Science in Estonia where he investigates the properties of nanomaterials for targeted applications that include: water purification (heavy metal ions extraction), the development of biocidal coating, the development of nanocomposites for photocurrent generation (in collaboration with Minatec, Grenoble), the using nanoadditives in jet fuel to decrease air freight carbon footprint, and they also investigate new possible treatments against cancer (in collaboration with LBN, Montpellier). He presently leads a team grant project (PRG2115) and coordinates a Thematic research and development program grant (Tem-TA144). He has more than 88 peer-reviewed publications with H-index=27, 5 book chapters and 6 patents. He is chief scientist in his Start-up Company (PRO-1 NANOSolutions), and more information can be found in www.rauwel.eu.

Esther Vazquez Gomez

Autonomous University of Barcelona, Spain

Title: ***"Targeting metastatic CXCR4+ cancers through self-assembled, self-delivered cytotoxic proteins"***

Esther Vázquez is a Senior Researcher at the Institute of Biotechnology and Biomedicine of the Autonomous University of Barcelona (UAB), and Associate Professor at the Department of Genetics and Microbiology. At the UAB she is leading a team focused on the development of new therapeutic tools for protein-based drug delivery. In order to translate the new nanomedicines into therapeutic products for clinical use, she has co- founded a spin-off from the UAB, Nanoligent, of which she is member of the scientific advisory board. Dr. Vázquez is PI of the Nanobiotechnology group that belongs to the research network of excellence CIBER in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN) since 2007. In the whole of her scientific career, she has led or participated in 99 projects, some through agreements with private companies, focused on the production of multifunctional protein carriers for use as therapeutic biomaterials. She is the author of more than 190 publications in international journals, >95% in Q1; she has directed 12 PhD theses and participated as inventor of eleven patents, six of which have already been licensed.

Frank Marken

University of Bath, United Kingdom

Title: **"Intrinsically Microporous Polymer in Electrochemistry"**

Professor Frank Marken is a distinguished chemist at the University of Bath, specializing in electrochemistry with applications in water treatment, solar energy, and sensing technologies.

His research focuses on developing innovative electrochemical technologies, including oxide nanostructures for electrocatalysis, liquid-liquid triple phase junction processes, bio-electrochemical systems, and the enhancement of electrochemical reactions using ultrasound, microwaves, and sunlight. He has also explored solid-state electrochemical processing, iontronics, ionic diodes in desalination, and paired organic syntheses.

In recognition of his contributions, Professor Marken was awarded the Theophilus Redwood Lectureship by the Royal Society of Chemistry's Analytical Division in 2009 and the Geoffrey Barker Medal for electrochemistry in 2018. He was also elected as a Fellow of the International Society of Electrochemistry in 2019.

Throughout his career, he has published over 530 research papers and supervised numerous doctoral students, significantly advancing the field of electrochemistry.

Ioan-Cezar MARCU
University of Bucharest, Bucharest, Romania
Title: ***"Highly effective hydrodeoxygenation catalysts obtained from transition-metal-containing layered double hydroxide precursors"***

Prof. Marcu got his BSc in Chemistry & Physics in 1995, and his MSc in Heterogeneous Catalysis in 1996 at the University of Bucharest. In 2002 he received his PhD in Catalysis at the Institute of Catalysis, University "Claude Bernard" Lyon 1, France, and was appointed as a lecturer at the Faculty of Chemistry of the University of Bucharest. From October 2006 to September 2007, he worked as a post -doctoral researcher at the Institute Charles Gerhardt of Montpellier, France, then, starting from 2007, he became a Senior Researcher at the Research Center for Catalysts and Catalytic Processes of the University of Bucharest. He got his Habilitation in Catalysis in 2013, and was appointed Professor of Chemical Technology and Catalysis at the University of Bucharest in February 2020. Currently he is the Head of Department of Inorganic & Organic Chemistry, Biochemistry & Catalysis of the University of Bucharest. His research interests cover the field of catalysis by metal oxides, including layered double hydroxide-derived oxides. He co-authored more than 80 research papers, including three book chapters and four encyclopedia articles.

Ivan Khalakhan
Charles University, Prague, Czech Republic
Title: ***"Compositional design strategy for optimizing ORR catalyst performance and durability"***

Prof. Dr. Ivan Khalakhan is an Associate Professor at the Nanomaterials Group of Charles University in Prague. He earned his PhD in Physics of Surfaces and Interfaces from Charles University in 2013. He has also conducted research stays at the National Institute for Materials Science (Tsukuba, Japan), Graz University of Technology (Graz, Austria), and the Helmholtz Institute Erlangen-Nürnberg for Renewable Energy (Erlangen, Germany). His work specializes in surface and interface physics and electrochemistry, focusing on the investigation of the physicochemical and electrochemical properties of metal, metal-oxide, bi- and multimetallic catalysts for electrochemical energy conversion technologies. Prof. Khalakhan has published over 110 scientific articles (h-index 27).

Ivana Vinkovic Vrcek
Institute for Medical Research and Occupational Health, Zagreb, Croatia
Title: ***"Endocrine disrupting activity of complex mixtures with plastic nanoparticles"***

Prof. Dr. Ivana Vinković Vrček is employed as Scientific Adviser Tenure at the Institute for Medical Research and Occupational Health in Zagreb, and engaged as Titular Professor of Biochemistry at the Faculty of Medicine in Rijeka.

Dr Ivana Vinković Vrček has pioneered Safe-by-Design approach in Croatian nanomedicine. Her research group is a unique multidisciplinary team focused on interaction of nanomaterials with biological systems and development nano-enabled tools for biomedicine. She is leader of a number of national and international research projects and actively participates in Horizon 2020 and Horizon Europe projects. She supervised more than 10 PhD students and a number of PostDocs. Dr Vinković Vrček is a member of Thematic innovation council for health and quality of life of the Ministry of Economy, Entrepreneurship and Crafts of the Republic of Croatia. She is Croatian member in the European Food Safety Authority (EFSA) Scientific Network on Risk Assessment of Nanotechnologies in Food and Feed, nominated expert in the Cross-Cutting Working Group on Particle Risk Assessment at EFSA, Croatian expert in the Nanomaterials Expert Group (NMEG) of the European Chemical Agency (ECHA) and Head of Delegation of the Republic of Croatia in the Working Party on Manufactured Nanomaterials (WPMN) of the Organisation for Economic Co-operation and Development (OECD).

Iwona Rutkowska

University of Warsaw, Poland

Title: ***"Highly Concentrated Iodine/Iodide Electrolytes for Effective Charge Propagation and Storage in Redox Flow Batteries"***

Iwona A. Rutkowska is a faculty member in chemistry at University of Warsaw. Her current research focuses on materials chemistry and electrochemistry of nanostructured metal oxides, noble metal nanoparticles and functionalized carbons, organic and inorganic polymers with emphasis on electrocatalytic processes for energy conversion and storage as well as on mechanisms of charge propagation. Her recent activities has concentrated on oxidation of small organic fuels, oxygen reduction reaction, nitrogen reduction, carbon dioxide reduction at various experimental conditions, and on redox flow batteries. She is a member of The Electrochemical Society (ECS), American Chemical Society (ACS) and International Society of Electrochemistry (ISE). In ECS she has served on many committees and co-organized numerous symposia. Presently, she is a Treasurer of Physical and Analytical Division and a Member-at-Large in Executive Committee of European Section.

Janis Timoshenko

Fritz Haber Institute of Max Planck society, Berlin, Germany

Title: ***"Steering the reversible metal cluster formation in working electrocatalysts with subnanometer accuracy"***

Janis Timoshenko is the group leader of the "Operando Hard X-ray spectroscopy" group in the Interface Science Department of Fritz Haber Institute of Max Planck society in Berlin. He received his PhD in solid state physics in 2015 from the University of Latvia. He then went for postdoctoral position at Stony Brook University, New York. In 2018 he joined the Department of Interface Science of the Fritz-Haber Institute. His research interests are synchrotron-based investigations of catalyst and nanomaterial transformations under working conditions, and the development of simulation-based and machine learning-based approaches for spectroscopic data interpretation. For the development of new data analysis methods in the field of X-ray absorption spectroscopy, in 2022 he received the Farrel Lytle Prize (Young Scientists Award for Theory and Instrumentation) of the International X-Ray Absorption Society. He has co-authored over 100 publications on the topics of operando studies of functional materials and spectroscopic data analysis.

Josep Puigmarti-Luis

University of Barcelona, Barcelona, Spain

Title: ***"Revolutionizing materials engineering and processing with microfluidic tools"***

Prof. Dr. Josep Puigmartí-Luis is a Full Professor at University of Barcelona, working on controlled synthesis of functional materials with the aid of microfluidic technologies. His work in supramolecular and flow chemistry, has been awarded with “Premi Antoni de Martí i Franquès de Ciències Químiques”, award from the Institut d’Estudis Catalans (2009), St. Jordi award from the Institut d’Estudis Catalans and the Societat Catalana de Química (2006) and an ETH fellowship in 2008. In 2012, he was appointed a Ramon Y Cajal (RyC) researcher, and in 2015 was awarded an ERC starting grant to study and control self-assembly processes of metal-organic based crystalline materials. In 2019, he was appointed as an ICREA Research Professor, and since 2020, his group is located at the University of Barcelona (UB). He was also awarded "Rising Star Award" from IEEE-3M Nano Community in 2023.

Jozef Keckes
University of Leoben, Leoben, Austria
Title: ***"In-situ nanoscale characterization of strains and microstructure in thin films"***

Jozef Keckes is a professor of material physics at Montanuniversität Leoben in Austria. His experimental research focuses on the extensive application of synchrotron X-ray diffraction in materials science, primarily for the characterization of thin films, coatings, metals, microelectronic components, and cellulosic materials. His work addresses both fundamental and applied aspects, analyzing the correlation between microstructure and strain on one side and the functional properties of materials on the other. A key focus of his research is the investigation of materials under operando and in-situ conditions, integrating a range of external stimuli to replicate real-world environments. This approach involves the incorporation of mechanical testing, controlled thermal conditions, and hydrogen charging directly into synchrotron experiments. These methodologies aim to uncover changes in strain and stress distributions, material microstructure, phase transformations, and functional performance. Jozef Keckes also serves as an editor for the Journal of Applied Crystallography.

Jurriaan Huskens
Institute for Nanotechnology (MESA+), University of Twente, Netherlands
Title: ***"Multivalent Interactions in the Detection of DNA and Viruses"***

Jurriaan Huskens (1968) studied chemical engineering at the Eindhoven University of Technology, and obtained his PhD (1994) at the Delft University of Technology with Herman van Bekkum. After postdoctoral stays with Dean Sherry (UT Dallas) and Manfred Reetz (MPI Kohlenforschung), he became assistant professor (1998) with David Reinhoudt at the University of Twente, where he became full professor "Molecular Nanofabrication" in 2005. He received the Unilever Research Award 1990, a Marie Curie fellowship (1997), the Gold Medal 2007 of the Royal Netherlands Chemical Society, a Fellowship of the Institute of Advanced Study, Durham University, UK (2019) and an ERC Advanced Grant (2024). Present research interests encompass: multivalency, virus and DNA sensing, supramolecular chemistry at interfaces, supramolecular materials, nanofabrication, and green chemistry.

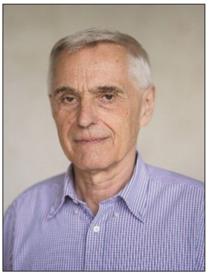
Klara Hernadi
University of Miskolc, Hungary
Title: ***"Experimental and theoretical aspects of CCVD synthesis of vertically aligned carbon nanotubes"***

Klara Hernadi received her MSc degree in chemistry from the University of Szeged in 1983, PhD/Candidate of Chemical Science from the Hungarian Sciences in 1993, and Doctor of Chemical Science in 2004 (HAS). She had short-term employments at Texas A&M University, at Facultés Universitaires Notre-Dame de la Paix (Namur Belgium) and at Ecole Polytechnique Federale de Lausanne (Switzerland). Currently she is a full professor at the University of Miskolc, previously she worked at the University of Szeged. Her current research interest covers various topics in the field of nanocrystalline materials (carbon nanotubes, photoactive semiconductors, nanocomposites, etc.

Krzysztof Pielichowski
Cracow University of Technology, Kraków, Poland
Title: ***"Synthesis and Characterization of Polyurethane/POSS Hybrid Nanomaterials"***

Professor Krzysztof Pielichowski, head of Department of Chemistry and Technology of Polymers, Cracow University of Technology, and chairman of the Polish Society of Calorimetry and Thermal Analysis, is an expert in polymer (nano) technology and chemistry, thermal analysis and flame retardancy, particularly in the areas of polymer nanocomposites with engineering polymers and hybrid organic-inorganic nanomaterials containing POSS. He is co-author (or editor) of nine books and over 160 papers with impact factor, including K. Pielichowski, T.M. Majka (Eds.), Polymer Composites with functionalized nanoparticles. Synthesis, properties and applications, Elsevier, Amsterdam 2019.

He has been recipient of a number of international and national awards, such as Kosciuszko Foundation Fellowship in 2000, Fulbright Fellowship Award in 2003 and the Rector of CUT Awards. He has also been a consultant or cooperating with a number of companies, such as ABB and Grupa Azoty SA. He is a member of the Committee of Chemistry and Committee of Chemical and Process Engineering of the Polish Academy of Sciences and Commission of Technical Sciences of the Polish Academy of Arts and Sciences. He was supervisor of 16 Ph.D. thesis (completed) and four currently running.



Ladislav Kavan
The Czech Academy of Sciences, Prague, Czech Republic
Title: ***"Band structure and electrochemistry of semiconducting oxides for energy applications"***

Prof. Dr. Ladislav Kavan is a senior scientist at the J. Heyrovsky Institute of Physical Chemistry, Czech Academy of Sciences. His has been a guest scientist at the Fritz Haber Institute in Berlin, Germany, the University of Gunma in Kiryu, Japan, and the Institute of Solid State and Materials Research in Dresden, Germany. He has also conducted many research stays at the Swiss Federal Institute of Technology in Lausanne (EPFL), where he has held the position of visiting professor of physical chemistry since 1988. Kavan's research focuses on nanocarbons, oxide semiconductors, dye-sensitized and perovskite solar cells, spectro/photo/electrochemistry, and lithium batteries. He has received nine European research grants (FP5-FP7, H2020) that supported work in photocatalysis, photovoltaics, and nanocarbons, including participation in the Graphene Flagship project. Among his accolades are the Award of the Czech Academy of Sciences for outstanding scientific results (2008), the František Běhounek Prize for promoting the Czech Republic and science within the European Research Area (2017), the silver medal from the Faculty of Science, Charles University (2019), and Metrohm's award for a lifetime contribution to electroanalytical chemistry (2021). He has co-authored three books and over 330 scientific publications, which have acquired over 18,700 citations; H-index = 63.

Lenka Zajickova
Central European Institute of Technology (CEITEC), Brno, Czechia
Title: ***"Fluorescent nitrogen-doped carbon quantum dots with similar optical properties yet different origins"***

Lenka Zajickova received her Ph.D. in plasma physics from the Masaryk University in Brno (Czech Republic) in 1999. She stayed as a post-doc at the Ruhr University Bochum (Germany), the Comenius University in Bratislava (Slovak Republic), and the University of Minnesota, Minneapolis (U.S.). Currently, she is leading the research group Plasma Technologies at the Central European Institute of Technology (CEITEC) in Brno and works as an Associate Professor at Masaryk University. Her work encompasses research on bioactive thin films prepared by plasma enhanced chemical vapor deposition (PECVD), plasma coatings on polymer nanofibers, and related investigation of the PECVD into complex 3D structures. She also works on synthesizing and functionalizing carbon nanomaterials, recently fluorescent carbon dots. Invited talks at international conferences, such as the Gaseous Electronics Conference, International Conference on Plasma Medicine, MRS Fall Meeting, and Gordon Research Conference on Plasma Processing Science, demonstrate her scientific community's recognition. She was the chair of Plathinium in 2023 (Antibes, France) and is a member of several conference committees (e.g., International Conference on Plasma Chemistry, Plasma Surface Engineering).

Luca Guerrini
Universitat Rovira I Virgili, Tarragona, Spain
Title: ***"Plasmon-enhanced Raman spectroscopy for sensing applications"***

Dr. Luca Guerrini is an Associate Professor of Chemistry at the Universitat Rovira i Virgili (URV) in Tarragona, Spain. He obtained his bachelor's degree summa cum laude in Industrial Chemistry from the University of Bologna in 2001. After gaining experience in the R&D sector of the chemical industry, he pursued a PhD in Physical Chemistry at the Spanish National Research Council (CSIC, Madrid), which he completed in 2009. He held postdoctoral positions at the University of Twente (Netherlands), the University of Strathclyde (United Kingdom), and the University of Vigo (Spain). He was later awarded a Marie Curie Intra-European Fellowship (IEF) at URV. Between 2015 and 2017, he served as Deputy Scientific Director at Medcom Advance (Spain), a spin-off company specializing in nanotechnology research and development for biomedical applications. In 2017, he was awarded a Ramón y Cajal Fellowship at URV, where he later became an Associate Professor in 2022. His research focuses on the design of plasmonic nanomaterials for optical sensing, with a particular emphasis on detecting analytes of environmental and biomedical relevance.

Marco Anni

University of Salento, Italy

Title: ***"Ligand and environment dependence of the spontaneous and stimulated emission properties of fully inorganic perovskite nanocrystals"***

Marco Anni is Associate Professor of Experimental Physics at University of Salento (Italy). From 2006 he is Director of the Photonic Laboratory of the Mathematics and Physics Department. He graduated in Physics in 1998 and completed his PhD in Physic in 2001, both at the University of Salento. His main research expertise is in the field of optical spectroscopy of semiconductors, mainly conjugated molecules and lead halide perovskites, with particular attention to light amplification and lasing processes. He is author of about 140 papers in international journals.

Maria Lucia Curri

University of Bari Aldo Moro, Italy

Title: ***"Tailoring functional nanomaterials for sustainable solutions to complex energy and environmental challenges"***

Maria Lucia Curri (b. 1968) is full professor of Physical Chemistry, University of Bari Aldo Moro (Italy), and Associate Research Scientist at the Institute for Physical and Chemical Processes of the Italian National Research Council (IPCF-CNR). She obtained her PhD in Chemistry from the University of Bari in 1997. Her research lies in the field of materials chemistry, with a focus on the development of innovative strategies for the synthesis and functionalization of colloidal nanocrystal -based inorganic and hybrid materials, aimed at applications in photocatalysis, energy conversion and storage, (bio)sensing, and biomedicine. She has been principal investigator of numerous national and EU-funded research projects in these domains. Author of over 260 peer-reviewed publications, she is a Fellow of the Royal Society of Chemistry (FRSC), Vice President of Italian National Interuniversity Consortium of Materials Science and Technology (INSTM), Associate Editor of Physical Chemistry Chemical Physics, and former Panel Chair of the ERC PE5 Consolidator Grants.

Mario Palacios-Corella

University of Barcelona, Barcelona, Spain

Title: ***"Why Turbulent Mixing Sucks (It's Not You)"***

Dr. Mario Palacios is a materials chemist and Junior Leader "La Caixa" Fellow at the University of Barcelona, where he develops nanoscale materials for biomedical applications and works on the controlled integration of functional systems using microfluidic platforms. He earned his PhD in Nanoscience and Nanotechnology from the University of Valencia in 2021, specializing in molecular magnetic systems. He later conducted postdoctoral research in the Czech Republic on micromotors, 3D printing, and 2D materials, before joining the Ibañez group at IST Austria to advance sustainable battery technologies based on Prussian Blue analogs.

Masazumi Fujiwara

Okayama University*, Okayama, Japan*

Title: ***"Nanodiamond quantum thermometers and their applications"***

Masazumi Fujiwara is a Professor at the Department of Chemistry at Okayama University, Japan.

He leads the Nanochemistry Group, focusing on nanodiamond-based quantum sensing for chemical and biological applications.

Currently, he serves as the PI for several research projects, including those funded by Grant-in-Aid (A) and the International Strategic Grant (A) by JSPS, which explore diamond quantum thermometry.

Additionally, he is a Co-PI in the JST-ASPIRE International Strategic Partnership Project for Quantum Sensing.

Maya Bar Sadan

Ben-Gurion University of the Negev, Israel

Title: ***"Innovative Phosphides for Enhanced Hydrogen Evolution and Alcohol Oxidation Catalysis"***

Prof. Maya Bar Sadan is the Head of the Department of Chemistry at Ben-Gurion University of the Negev, Israel. She earned her Ph.D. in Chemistry and Materials Science from the Weizmann Institute of Science in 2007. Following her doctorate, she was awarded a Minerva Foundation (Max Planck Society) postdoctoral fellowship, conducting research at the Institute of Solid-State Research and the Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons in Jülich, Germany. She joined Ben-Gurion University in 2011.
Prof. Bar Sadan has been recognized for her excellence in both teaching and research. She received the Charles Roth Prize for Teaching Excellence from Ben-Gurion University in 2014 and the Krill Prize for Scientific Excellence from the Wolf Foundation in 2016. Her research focuses on correlating macroscopic properties, such as catalytic activity and optical behavior, with atomic-scale structures. Leveraging advanced high-resolution transmission electron microscopy and spectroscopy, she aims to design innovative electrocatalysts and photocatalysts.

Nejc Hodnik

National Institute of Chemistry, Ljubljana, Slovenia

Title: ***"Our Advanced Characterization Platform for Studying Nanostructured Materials as Electrocatalysts for Fuel Cells and Electrolyzers"***

Prof. Dr. Nejc Hodnik is the head of the Laboratory for Electrocatalysis (ElectroCat) at the National Institute of Chemistry in Ljubljana and an adjunct professor at the University of Nova Gorica. He earned his PhD from the University of Ljubljana in 2013 and further advanced his research as a Marie Curie IEF Scholar at the Max Planck Institute in Düsseldorf, Germany. His work specializes in electrocatalysis for fuel cells and electrolyzers, with key contributions to nanomaterial development, advanced electrochemical methods, and precious metal recycling. Prof. Hodnik has published over 120 scientific articles (h-index 38), holds three patents, and has mentored more than 10 PhD students. He leads projects, including an ERC Starting Grant and NATO SPS, focusing on energy conversion, nanotechnology and sustainable technologies.

Protima Rauwel

Estonian Aviation Academy, Department of Aeronautical Engineering, Estonia

Title: ***"Fuel nano additives produced from food waste to reduce aviation gas turbine carbon footprint and make sustainable aviation fuel suitable for air freight"***

Prof. Protima Rauwel obtained her PhD in 2005 from the University of Caen, France. She subsequently conducted postdoctoral research at the University of Aveiro, Portugal, and the University of Oslo, Norway. In Estonia, she has served as Chair Professor of Energy Applications and is currently a Professor of Applied Nanotechnology. Her expertise lies in the optical and nanoscale characterization of materials, as well as in the synthesis and application of nanomaterials. These materials are applied in photodiodes, photocatalysis, and photoelectrochemical diodes. She has also contributed to several interdisciplinary research projects in nanomedicine.Her current research at the Estonian Aviation Academy focuses on the use of nanoadditives in sustainable aviation fuels to reduce carbon emissions and promote environmental sustainability. More broadly, she is committed to developing sustainable materials and minimizing environmental impact in various applications. She holds three patents, has authored over 100 articles, five books or thematic issues, and several book chapters. Her h-index on Scopus is 32.

Rasa Pauliukaite

Center for Physical Sciences and Technology, Vilnius, Lithuania

Title:***"Carbon nanomaterials for electrochemical sensing"***

Prof. Dr. Rasa Pauliukaite is a chief researcher at the Center for Physical Sciences and Technology (FTMC) in Lithuania, where she is also head of the Functional Nanomaterials Laboratory at the Department of Nanoengineering. She received her Ph.D. in Natural Sciences, (Physical) Chemistry from the Institute of Chemistry, Vilnius, Lithuania in 1998. Since 2000, she has held several postdoctoral positions in different European groups such as Karl-Franzens University Graz, Austria; National Institute of Chemistry, Ljubljana, Slovenia; ETH Zurich, Switzerland; and University of Coimbra, Portugal. During postdoctoral fellowships she changed her research interests to electroanalysis and development of electrochemical (bio)sensors. She returned to Vilnius and joined FTMC in 2010. Her research interests are focused on the development of (bio)sensors, including new materials, conducting polymers, sensor architecture, etc.

Salvador Pané i Vidal

Swiss Federal Institute of Technology (ETH) Zurich, Zurich, Switzerland

Title: ***"Magnetic Micro- and Nanorobots"***

Prof. Salvador Pané i Vidal (Barcelona 1980) is a Professor of Materials for Robotics at the Institute of Robotics and Intelligent Systems (IRIS) and co-director of the Multi-Scale Robotics Lab at ETH Zürich. He earned his B.S. (2003), M.S. (2004), and a Ph.D. in Chemistry (2008) from the University of Barcelona (UB). Prof. Pané has authored over 200 articles in international peer-reviewed journals and books on science education. His current focus is on integrating chemistry and materials with small-scale robotics. He has served as coordinator for the FET Open project (MANAQA) and FET Proactive (ANGIE). In 2013, he received the Starting Grant from the European Research Council (ERC). From 2015 to 2019, he chaired the COST Action "e-MINDS" and represents Switzerland in the European Academy of Surface Technology. Prof. Pané is a co-founder of Magnes AG, Oxyle AG and Swiss Vascular AG. In 2017, he was honored with the Big-on-Small Award at the International Conference on Manipulation, Automation, and Robotics at Small Scales (MARSS) and received a Consolidator Grant (ERC) in 2019, along with the ERC Proof-of-Concept grant in the same year.

Vincenzo Guidi

University of Ferrara, Ferrara, Italy

Title: ***"Functional metal oxides for gas sensing"***

The scientific activity has consisted of Semiconductor Physics and Nanosized Materials with particular emphasis to fabrication of sensing devices for indoor and outdoor measurements of gas concentrations, as finalized to the development of smart sensors for IoT. He applied such techniques to environmental monitoring in urban and industrial areas, precision agriculture, landfill monitoring, automobile and safety applications. In the last years, research activity was devoted to research and application of sensing devices for monitoring of gas pollutants and malodors, detection of volatile organic compounds for agri-food applications, monitoring of green-house gases and CO2 for decarbonization processes. For such applications he also developed advanced deep learning methods for analysis of the responses of arrays of sensors.

He patented some devices in semiconductors and optoelectronics and was author of 28 invited talks, keynote talks and plenary talks at international conferences as well as editor, guest editor of international scientific journals as well as organizer of about ten international corferences/workshops. He has been PI or unit responsible for several regional, national and European projects as well as referent of experiments at international facilities.He has been team leader of the Sensors and Semiconductors Lab (SSL) at Ferrara University since 2010. SSL consists of several labs, including a 125 m2 clean-room facility, equipped with high-quality and modern instrumentation for semiconductor studies, for an investment of more than 5 million euros. There are currently four main activities being pursued at SSL, namely silicon microfabrication for investigation of coherent effect in crystals, gas sensing via chemoresistive materials, hard x-ray optics through curved crystals and concentrated photovoltaics. At SSL, counting 25 people involved (5 staff members), basic investigations on semiconductors are harmonized with a traditional inclination toward applied physics. He mentored more than 35 PhD students in his career.

He served as head of the Department of Physics and Earth Sciences (2018-2024) and is currently director of the Institute of Superior Studies at University of Ferrara and formerly pro-rector for Sustainability Politics at the same university.

Vojtech Uhlir
Brno University of Technology, Brno, Czech Republic
Title: ***"Advanced Imaging of Metamagnetic Micro- and Nano-Structures: From Fundamentals to Biomedicine"***

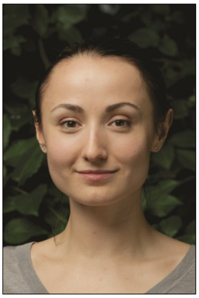
Vojtěch Uhlíř received his Ph.D. in Physics of Materials and Physical and Materials Engineering in 2010 from Université de Grenoble and Brno University of Technology, respectively, for his work on current-induced magnetization dynamics. After postdoctoral appointment at University of California, San Diego he moved to Czechia in 2016 and holds a Research Group Leader position at Central European Institute of Technology in Brno. His current research is focused on metamagnetic materials under strong spatial confinement, high-resolution magnetic imaging, and ultrafast magnetization dynamics.

Rafael Muñoz-Espí
University of Valencia, Paterna, Spain
Title: *"Tailored Polymer Nanoparticles for Heterogeneous Asymmetric Organocatalysis and Transition Metal Catalysis"*

Rafael Muñoz-Espí is an Associate Professor of Physical Chemistry at the University of Valencia. He earned his Chemistry degree there in 2001 and completed his PhD in 2006 at the Johannes Gutenberg University of Mainz, Germany, while working at the Max Planck Institute for Polymer Research (MPIP). From 2007 to 2009, he was a Postdoctoral Associate at Stony Brook University (USA), with regular work at the Brookhaven National Laboratory. He returned to the MPIP in 2009, where he led the "Polymer/Inorganic Hybrid Colloids" group until 2015. That year, he returned to Valencia as a Ramón y Cajal Fellow and became Associate Professor in 2021. His research focuses on polymer and hybrid nanoparticles, nanoencapsulation, and crystallization in colloidal systems. He has authored over 100 peer-reviewed publications and has held visiting positions in Israel, Italy, and Ecuador.

Nermin Seda Kehr
Izmir Institute of Technology, Izmir, Turkey
Title: *"BioHybrid Hydrogel with Oxygen, Drug and Probiotic Metabolite Co-Delivery"*

Nermin Seda Kehr did her Ph.D. at the University of Münster. After postdoctoral research at the University of Münster and University of Strasbourg, she built up her own research group. She received the National Scientific qualification as Full Professor for the disciplinary field "Bioengineering" in the Italian higher education system and completed her habilitation with the Venia Legendi award in Organic Chemistry at the University of Münster in 2021. She is currently working as an Associate Professor at Izmir Institute of Technology. Her research interests include functional nanomaterials and surfaces, injectable nanocomposite hydrogels, 3D bioprinting and local drug delivery.



Larysa Baraban
Helmholtz-Zentrum Dresden-Rossendorf, Germany
Title: "Role of nano- and microreactors for tumour modeling and clinical diagnostics"

Prof. Dr. Larysa Baraban is the professor at the Faculty of Medicine Carl Gustav Carus of Dresden University of Technology. She is the head of department Nanomicrosystems for life sciences and is the ERC Consolidator Grantee, keeping the main mission of her research to bridge the materials science and nanotechnology with the world of cancer research. She strongly contributes to the idea of the development of the nanoscopic biosensors and makes the links between the materials and life sciences.

Organising Committee

Alla Zak

Holon Institute of Technology, Holon, Israel

Title: ***"Inorganic nanotubes: synthesis properties and applications"***

Prof. Alla Zak is Dean of the Faculty of Sciences and Head of the Nanomaterials Laboratory at HIT, and Scientific Advisor in the Dept. of Molecular Chemistry and Materials Science at the Weizmann Institute of Science. An expert in nanoscience and nanotechnology, she holds a PhD from the Dept. of Materials and Interfaces at the Weizmann Institute, and an MSc and BSc in Physics from Kishinev University in Moldova. Before joining HIT in 2012 she served as Chief Scientist at NanoMaterials Ltd. Prof. Zak holds 4 patents, has published more than 90 scientific papers, participated in more than 100 scientific conferences worldwide, and received several national and international awards and grants, in recognition of her excellence and innovation in research.

The research of A. Zak is focused on synthetic of nanospheres and nanotubes from layered transition metal dichalcogenides useful in various electro-mechanical or electro-optical implementations. The unique properties of these material already proved their effectiveness for such applications as strengthening of polymers, piezoresistive sensors, effective catalyst for electrochemical hydrogen evolution reaction (HER), as solar cells, memory for artificial vision system and others.

Dominik Eder

Vienna University of Technology (TU Vienna), Vienna, Austria

Title: ***"Water-stable Metal-organic Frameworks for Photoelectrocatalytic Water Treatment and Solar Fuel Production"***

Prof. Dominik Eder is head of the "Molecular Materials Chemistry" division at IMC at TU Wien. His division currently consists of 4 subgroups (faculty members), 4 non-scientific staff and about 20 students and postdocs. His research interests include the synthesis and characterization of nanocarbon hybrids, 0-2D molecular inorganics, metal organic frameworks (MOFs), zeolites and ordered mesoporous transition metal oxides and their in-depth fundamental evaluation for catalysis/photocatalysis, photovoltaics and electrochemical storage applications. His group has been instrumental in the introduction and development of nanocarbon-inorganic hybrid materials as a new class of functional composites.

Pawel Kulesza

University of Warsaw, Warsaw, Poland

Title: ***"Hybrid Catalytic Systems for Electrochemical Conversion of Inert Inorganic Molecules: Reduction of Carbon Dioxide and Nitrogen"***

Pawel J. Kulesza is Professor of Chemistry at University of Warsaw, Fellow of the Electrochemical Society, and Member of the Polish Academy of Sciences. His recent interests concern development and characterization of hierarchical and functionalized inorganic nanomaterials and interfaces of importance to electrocatalysis, photoelectrochemistry, analytical chemistry, energy conversion and storage. He is Associate Editor of *Electrochimica Acta* (Elsevier) and a member of editorial boards of *Journal of Solid State Electrochemistry*, *Electrocatalysis, Russian Journal of Electrochemistry* (Springer) and *Catalysts* (MDPI). In Electrochemical Society, in addition to activity in many committees and organization of symposia at meetings, he has served as Chair of Physical Analytical Electrochemistry Division and Chair of European Section. He is a recipient of Alessandro Volta Medal of Electrochemical Society (2024). He is also a member of American Chemical Society, International Society of Electrochemistry, and Polish Chemical Society.

Saim Emin

University of Nova Gorica, Nova Gorica, Slovenia

Title: "Utilization of α-Fe_2O_3 Thin Films in Photoelectrochemical Oxidation Studies"

Saim Emin obtained his Bachelor of Science from the University of Sofia "St. Kliment Ohridski" in Bulgaria in 2003. He then completed his Master of Science and Ph.D. in Chemistry at Saitama University, Japan, in 2007 and 2010, respectively. He then undertook postdoctoral appointments at the National Institute for Material Science (NIMS) in Japan and the University of Nova Gorica (UNG) in Slovenia. Dr. Emin previously held a junior professorship in the Faculty for Environmental Sciences at UNG before becoming an associate professor. He received the individual Marie Skłodowska-Curie Career Integration Grant from the European Commission. Dr. Emin's research centers on utilizing nanotechnology to create functional materials, particularly in the fields of photovoltaics, electrocatalysis, water splitting, and CO2 conversion. He is acknowledged for his contributions to the subject and acts as an editor for the "Symmetry" journal published by MDPI. Dr. Emin is also the founder of the European Nanoscience and Nanotechnology Association. He has been involved in organizing the annual International Conference on Functional Nanomaterials and Nanodevices series since 2017. Dr. Emin has a prolific publication record, having produced over 50 papers and accumulating more than 1150 citations for his work.

Plenary lectures

Symmetry and nonlinear responses in nanomaterials

Yoshi Iwasa[a]

[a] *RIKEN Center for Emergent Matter Science, Hirosawa 2-1, Wako 351-0198, Japan*
E-mail: iwasay@riken.jp

Keyword: 2D materials, van der Waals interfaces, symmetry engineering, nonlinear responses, quantum geometry

A noticeable advantage of nanomaterials including 2D materials is that their structural symmetry can be changed by forming nanostructures, i.e., isolating monolayers or making van der Waals (vdW) heterostructures, even though they are chemically identical materials. This is in marked contrast with bulk single crystals, where the structural symmetry is uniquely defined by their space group. For instance, research on 2D transition metal dichalcogenides was triggered by the broken inversion symmetry in exfoliated monolayer MoS_2, in marked contranst with the centrosymmetric bulk MoS_2 single crystals. Here we discuss the emergence of NONLINEAR responses induced by the symmetry engineering of 2D and related materials. The nonlinear responses include bulk photovoltaic effect (BPVE) [1-3], nonreciprocal transport [4], and superconducting diode effect (SDE) [5]. These nonlinear responses, some of which are tightly connected with the quantum geometric properties of materials, can be controlled by the manipulation of nanostrctures, such as forming nanotube structure, van der Waals interfaces, and uniaxial strain effects.

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Nanomaterials for Enzymatic Bioelectrocatalysis

Shelley D. Minteer[a,b]

[a] *NSF Center for Synthetic Organic Electrochemistry, University of Utah, Salt Lake City, UT, USA*
[b] *Department of Chemistry, Missouri University of Science and Technology, Rolla, MO, USA*
E-mail: minteer@chem.utah.edu and *shelley.minteer@mst.edu*

Keyword: Electrosynthesis, fuel cells, sensors

This talk will discuss the need for nanomaterials for enzymatic bioelectrocatalysis for applications ranging from biosensors to energy conversion to electrosynthesis. After introducing the need, this talk will discuss the design, synthesis, and characterization of nanomaterials and nanocomposites for these applications, including oxygen reduction reactions in fuel cells and self-powered biosensors and nitrogen reduction in ammonia electrosynthesis. Finally, this talk will discuss future strategies for tailoring nanomaterials for enzymatic bioelectrocatalytic applications.

Nanostructured functional materials and their applications

Ulrich Wiesner[a,b]

[a] *Department of Materials Science and Engineering, Cornell University, Ithaca, New York 14853, USA*
[b] *Department of Design Tech, Cornell University, Ithaca, New York 14853, USA*
E-mail: ubw1@cornell.edu

Keyword: Block Copolymers, Self-Assembly, Porous Materials

Block copolymer self-assembly (BCP SA), a hallmark of soft condensed matter science, has been shown to enable structure-direction of a wide range of organic-inorganic hybrid as well as inorganic materials, from amorphous silicates and aluminosilicates, high-temperature non-oxides, carbons, and crystalline transition metal oxides all the way to semiconductors and metals. After removal of the organic moieties from the as-made mesostructured polymer-inorganic hybrid materials, the resulting periodically ordered and high-surface area mesoporous inorganic solids have been used in a plethora of applications, ranging from separation, across energy conversion and storage, all the way to catalysis and photocatalysis.

In this presentation work by the Wiesner group at Cornell on block copolymer self-assembly derived advanced functional porous materials and devices is discussed. The emphasis will be on the development of wet chemical methodologies towards controlled porous structures resulting in specific functions. Experiments will be compared to theoretical predictions to provide physical insights into formation principles and specific properties. The aim of the described work is to understand the underlying fundamental chemical, thermodynamic and kinetic formation principles as well as nanostructure-property correlations enabling generalization of results over a wide class of porous materials systems. Work will cover structure formation at or close to the thermodynamic equilibrium as well as approaches where systems are systematically driven away from equilibrium. A particular emphasis of the work is to generate function from integration of structure formation ranging from the near-molecular all the way to the macro-scale. Examples will include shape control of hierarchical porous BCP SA directed all-organic thin films via transient laser heating and their conversion into 3D periodic mesoporous semiconductors, BCP SA directed gyroidal mesoporous carbons for the realization of three-dimensional (3D) battery architectures, as well as BCP SA directed quantum metamaterials in the form of hierarchically structured mesoporous superconductors from additive manufacturing/3D printing.

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Inorganic nanotubes: From WS_2 to "misfit" compounds

Reshef Tenne

Department of Molecular Science Chemistry and Materials Science, Weizmann Institute, Rehovot 76100, Israel
E-mail: reshef.tenne@weizmann.ac.il

Update on the synthesis and characterization of new inorganic nanotubes from 2D compounds, like W $(S,Se)_2$[1] will be given. The strong coupling between optical cavity modes confined in the nanotube and the exitonic transitions have been studied in some detail.[1,2] Virtually recently, an “artificial recording eye” combining vison, storage and writing power has been established by a 4x4 array of WS_2 nanotubes.[3] Recent progress in mechanically reinforcing different polymers, will be briefly discussed.

Different nanotubes from quaternary “misfit” layered compounds (MLC) have been realized in recent years. In one recent case, the strong chemical affinity of the RE atoms towards sulfur atoms and that of selenium towards the tantalum atoms, led to the synthesis of highly anisotropic nanotubes, like RES-$TaSe_2$ and RE-$(TaSe_2)_2$ (with RE=La, Sm) with extremely large (local) dipole moment.[4] The high-temperature stability of such MLC nanotubes were studied with the help of synchrotron-based X-ray absorption and scattering techniques.[5] Such nanotubes offer unique behavior, like 1D superconductivity, etc., suitable for quantum technologies.

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Keynote lectures

Chemical Evolution of Nanocarriers for RNA Delivery and Genome Editing

Ernst Wagner[ab]

[a] *Pharmaceutical Biotechnology, Ludwig-Maximilians-Universität (LMU), Butenandtstr. 5-13, 81377 Munich, Germany*
[b] *Center for Nanoscience (CeNS), Ludwig-Maximilians-Universität (LMU), Munich, Germany*
E-mail: ernst.wagner@lmu.de

Keyword: nucleic acid delivery, nanobiotechnology, CRISPR Cas9, mRNA, siRNA

33 gene therapies and 35 RNA therapies have been approved as medical drugs. Nevertheless, improved delivery of RNA drugs remains a key requirement. Commonly, therapeutic delivery requires formulation into nanoparticle that are stable in blood and other biological extracellular fluids, are targeted to specific organs and tissues, taken up by target cells and are intracellularly released in bioactive form. Our lab focuses on a bio-inspired chemical evolution strategy. We incorporate artificial amino acids such as tetraethylene pentamino succinic acid (Stp) or lipo amino fatty acids (LAF) into cationizable xenopeptide (XP) libraries, suitable for packaging siRNA, mRNA, or CRISPER Cas9 into dynamic nanoparticles. These sequence-defined molecular libraries are subjected to chemical evolution tailored for a specific application, enabling identification of new RNA carriers. Further refinement of carriers is supported by molecular dynamics and machine learning.

Using solid-phase peptide synthesis in few (4-8) simple coupling steps with different sequences and topologies (such as bundles, U-shapes), we identified double pH-responsive lipo-XPs as small, optionally biodegradable molecules with outstanding dynamic nucleic acid delivery characteristics.

Enhanced escape out of intracellular acidic vesicles termed endosomes turned out to be a key factor for RNA delivery. A pH-dependent polarity of LAF was implemented by a central tertiary amine that disrupts the hydrophobic character once protonated, resulting in drastic pH-dependent change in the distribution from lipid phase (physiological pH) to lipid/water interface (endosomal pH), as supported by molecular dynamics calculations and SAXS. Activity was maintained in full serum and at very low dosage of only ~two nanoparticles/cell. Applications include mRNA expression in several organs upon systemic administration, in vivo gene silencing by siRNA-LNPs with superior activity in liver endothelial cells or, when including targeting ligand cRGDfk, in tumor endothelial cells. Potent carriers for CRISPER Cas9/sgRNA trigger genome editing in cell culture and in vivo.

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“RadioNano Therapeutics” for Cancer by Functionally Programmed Medical Nanodevices

Naoki Komatsu

Graduate School of Human and Environmental Studies, Kyoto University, Sakyo-ku, Kyoto 606-8501, Japan
E-mail: komatsu.naoki.7w@kyoto-u.ac.jp

Keyword: Tumor, Therapy, Neutron, Photon, Nanoparticles, Boron-10, Sensitizer

Nanomedicine is promising to improve the conventional cancer medicine by making diagnosis and therapy more accurate and more effective in a more personalized manner. A key of the cancer nanomedicine is construction of medical nanodevices by programming most of the following functions to nanoparticles (NPs); A) high dispersibility in a physiological environment, B) high stealth efficiency to slip through the trap by liver and spleen, C) high targeting efficiency to cancer tissue, D) clear visualization of cancer for diagnosis, and E) high anticancer activity for treatment [1].

In our approach, poly(glycerol) (PG), containing a hydroxy group at every monomer unit, was found as a better alternative to poly(ethylene glycol) (PEG), the most commonly used hydrophilic polymer, giving A) high dispersibility to inorganic NPs [2]. Although most of the inorganic NPs are not dense in functional groups, the hyperbranched structure with many hydroxy groups in PG turns the less functional surface into highly functional one, imparting not only good hydrophilicity, but also B) high stealth efficiency we reported recently [3]. In addition, a number of hydroxy groups in PG afford the structural or functional extensibility to introduce the additional layer or function. This enables us to design and construct a three-layer architecture consisting of core inorganic NP, hydrophilic and stealthy PG layer, and functional molecule layer. Owing to the versatility of the three-layer model, the rest of the above functions C) – E) can be programed to the NP core and/or the outmost layer in nanodevices [4-7].

In this keynote, I will present functional programming of inorganic NPs as medical nanodevices and their application to “RadioNano Therapeutics” for cancer [1, 6, 7].

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Session:
Energy Conversion and Storage Materials

Invited Lectures

Regular Lectures

Poster Presentations

Design of organic and bio-inspired materials for the development of solar energy conversion devices

Carmen Coppola[a,b], Maria Laura Parisi[a,b,c], Adalgisa Sinicropi[a,b,c]

[a] *Department of Biotechnology, Chemistry and Pharmacy, R²ES Lab, University of Siena, Siena, Italy*
[b] *Institute of Chemistry of Organometallic Compounds (CNR-ICCOM), Sesto Fiorentino, Italy*
[c] *LifeCARES srl - Life Cycle Assessment Renewable Energy and Sustainability, Arezzo, Italy.*
E-mail: adalgisa.sinicropi@unisi.it

Keyword: Photovoltaics, Solar Energy Materials, DFT, Machine Learning, QM/MM

The urgent demand for clean and sustainable energy has driven intense research into advanced solar energy materials for photovoltaic applications. Beyond conventional silicon-based photovoltaics, emerging technologies are drawing increasing attention due to their potential for flexible design, indoor applicability, and integration into building materials.

Computational modelling plays a crucial role in accelerating the discovery and optimization of these materials. In particular, combining data-driven techniques like machine learning (ML) with quantum mechanical methods such as density functional theory (DFT) enables rapid evaluation of candidate materials across vast chemical spaces. Additionally, hybrid quantum mechanics/molecular mechanics (QM/MM) approaches allow for the accurate simulation of chemical phenomena in complex molecular environments. These computational strategies significantly reduce the need for time-consuming experimental trials, facilitating targeted materials discovery.

In this contribution, we present two recent modelling studies. The first focuses on indoor dye-sensitized solar cells (DSSCs), where a two-stage ML-DFT protocol was developed to screen D–π–A, D–π–A'–A, and D–A'–π–A organic dyes. The model successfully identified three promising dye candidates for indoor DSSCs with predicted power conversion efficiencies above 29% under different artificial illumination conditions, and with good synthetic accessibility.
The second study investigates a bio-inspired hybrid system using bacteriorhodopsin (bR) adsorbed on anatase TiO_2 surfaces. bR has mainly been used as a TiO_2 sensitizer in photovoltaic and photoelectrochemical cells to convert solar energy into electricity or chemical fuels (e.g., H_2), respectively. We analyzed four adsorption orientations and their influence on spectral and electronic properties through steered molecular dynamics and QM/MM simulations. The developed bR/TiO2 models successfully allowed us to unveil the key protein–surface interactions and reproduce the spectral shifts observed upon adsorption. We concluded that the constructed models could provide a basis for future studies aiming to simulate the complex long-range electron transfer mechanism in bR/TiO2-based solar energy conversion devices as well as in engineering bR to achieve enhanced efficiencies.

These results highlight the power of computational strategies in guiding the design of next-generation solar energy materials and devices.

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Emerging energy harvesting from X-gradient: the case of low grade waste heat, CO2 and salinity gradient.

Andrea Lamberti[1,2]

[1] Istituto Italiano di Tecnologia, Center for Sustainable Future Technologies, Via Livorno 60, 10144 Torino, Italy
[2] Politecnico di Torino, Dipartimento di Scienza Applicata e Tecnologia (DISAT), Corso Duca Degli Abruzzi, 24, 10129 Torino, Italy
E-mail:andrea.lamberti@polito.it

Keyword: Supercapacitors, energy harvesting, energy storage, electrochemical integration

Following the successful development of the CO_2 capacitive mixing, which focuses on innovative CO_2 capture technologies [1], our research has now expanded toward the exploitation of low-grade waste heat for energy recovery. This new phase builds upon the core principles of capacitive mixing, integrating thermal energy harvesting systems into the broader context of carbon capture and sustainable energy conversion. The goal is to enhance the overall energy efficiency of industrial processes by recovering and converting low-temperature heat—typically released unused—into valuable energy, thereby reducing both CO_2 emissions and operational costs. By leveraging advanced materials, thermodynamic cycles, and system integration strategies, we aim to develop compact and modular solutions adaptable to various industrial settings. This research represents a significant step toward decarbonizing energy-intensive sectors, making carbon capture not only more effective but also energetically and economically sustainable.

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Acknowlegment

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Printable thermoelectric materials: from cell to modules

A. Reale[a]* S. Muhammad[a], S. Gococ[b], M. Franzini[c], S. Galliano[c], C. Barolo[c],

[a]Department of Electronic Engineering, CHOSE—Centre for Hybrid and Organic Solar Energy, University of Rome Tor Vergata, via del Politecnico 1, 00133 Rome, Italy
[b]Thermoelectric Research Laboratory, Faculty of Materials Science and Ceramics, AGH University of Krakow, Mickiewicza Ave. 30, PL30059 Krakow
[c]. Department of Chemistry and NIS Interdepartmental Centre, University of Turin, Via Pietro Giuria 7, Torino, 10125, Italy
E-mail: reale@uniroma2.it

Keyword: , Organic Thermoelectrics, Organic Semiconductor, Composites

The development of organic thermoelectric (TE) devices is a promising yet complex field [1, 2]. Several key factors are critical to achieving competitive performance and practical applicability. In general, the optimization of the Power Factor ($S^2\sigma$) is a complex task since in organic materials, these two parameters are often inversely related—increasing one typically reduces the other. Possible strategies include chemical and electrochemical doping to enhance σ without excessively degrading S, use of high-mobility polymers or organic semiconductors like PEDOT:PSS, P3HT, and small molecules, energy filtering and band engineering to decouple S and σ. Additionally, good TE performances require minimizing Thermal Conductivity (k). Organic materials typically exhibit low thermal conductivity (0.1–0.5 W/mK), which is beneficial for high ZT values. However, interfaces in composite materials can increase k, so maintaining low thermal transport is essential. To this extent, the use of nanostructuring, disordered phases, and phonon scattering mechanisms can help retain low k. Additionally, morphological and structural control is a powerful tool addressing molecular packing, crystallinity, and phase separation in organic blends, that greatly influence charge transport. Processing techniques (e.g., solvent selection, annealing, alignment) are crucial to optimize morphology for better TE performance. Other strategies are incorporating nanofillers such as carbon nanotubes, graphene, metal nanoparticles, or inorganic semiconductors into a polymer matrix, in order to improve electrical properties, possibly decoupling electrical conducibility to Seebeck response [3]. Care must be taken to maintain good dispersion and avoid aggregation, which can negatively impact both electrical and thermal properties.

Developing air-stable, moisture-resistant materials and robust encapsulation methods is crucial for long-term operation, especially in flexible or wearable applications. Solution processability is a major advantage of organic materials. Methods like inkjet printing, blade coating, and roll-to-roll processing are key for scalable manufacturing. Non halogenated solvents, bio-polymers, and low-energy processing aligns with sustainable development goals [4].

We will present a printable TE paste with graphene nanoplatelets (GNPs) and poly(3-hexylthiophene) (P3HT), using various filler-to-semiconductor ratios and doping strategies, together with the ceramic spacer comprising Titanium oxide nanoparticles (TiO_2 NPs). We will report our results on films, pellets, and module in both planar and 3D configurations. Doping has led to a significant enhancement in the electrical conductivity and Seebeck coefficient (S) for the films of G:P3HT composite, which increased from 40 S/m to 140 S/m, and from 35μV/K to 85μV/K, respectively, in the 1:2 ratio. Similarly, the power factor (PF) for thin films demonstrated a significant increase from 35 nW/mK2 to 1022 nW/mK2 following doping. We also investigated how the development of a three-dimensional structure, identified as a cylindrical pellet, effectively altered the dopant, filler, and spacer role. A refined G:P3HT (LiTFSI) pellet was employed to construct a thermoelectric (TE) module for practical performance evaluation, achieving a maximum power output (Pmax) of approximately 0.40μW/cm2. This methodology may serve as a guide for producing efficient, cost-effective TE materials.

Acknowledgments

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Compositional design strategy for optimizing ORR catalyst performance and durability

Ivan Khalakhan

Department of Surface and Plasma Science, Faculty of Mathematics and Physics, Charles University, V Holešovičkách 2, 180 00 Prague 8, Czech Republic
E-mail: khalakhan@gmail.com

Keywords: Fuel Cells, Oxygen Reduction Reaction, Activity-Stability Relationship

The advancement of energy conversion technologies such as proton-exchange membrane fuel cells (PEMFCs) relies on the development of oxygen reduction reaction (ORR) catalysts that combine high activity with long-term durability. So far, expensive and scarce platinum remains the benchmark ORR catalyst due to its excellent intrinsic activity and acceptable stability.

It has been well established that alloying platinum with inexpensive 3d transition or rare earth metals markedly enhance the catalyst cost-efficiency but significantly compromising its durability [1, 2]. On the contrary, the incorporation of gold into platinum has recently been proven as an effective strategy to stabilize the platinum catalyst [3, 4]. Yet, Pt–Au alloys neither improve ORR activity nor reduce overall catalyst cost. The delicate balance between activity and stability thus underscores the ongoing quest for optimal catalyst designs in fuel cell technology.

To address this challenge, we combine both strategies by preparing ternary PtNiAu alloys, in which each element serves a distinct purpose: Ni reduces cost and enhances ORR activity, while Au improves stability [5]. Model catalyst layers were fabricated by magnetron co-sputtering, which enables fine tuning of the composition which is essential to achieve an optimal balance between activity and durability. A systematic comparative analysis of the activity–stability relationship for compositionally tuned catalytic layers was conducted using a diverse range of complementary characterization techniques and electrochemistry, including Synchrotron Radiation Photoelectron Spectroscopy (SRPES), X-ray Diffraction (XRD), Rotating Disk Electrode (RDE) measurements, and Scanning Flow Cell coupled with Inductively Coupled Plasma Mass Spectrometry (SFC-ICP-MS). This approach allowed for a detailed investigation of how compositional modifications affect the interplay between ORR activity and stability, enabling the identification of optimal alloy configurations for cost-effective and durable ORR catalyst.

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Highly Concentrated Iodine/Iodide Electrolytes for Effective Charge Propagation and Storage in Redox Flow Batteries

Iwona A. Rutkowska, Justyna Lubera, Pawel J .Kulesza

Faculty of Chemistry, University of Warsaw, Pasteura 1, PL-02-093 Warsaw, Poland
E-mail: ilinek@chem.uw.edu.pl

The technology of redox flow batteries is an important option to store energy from the operating irregularly renewable energy sources. The perspectives concern stationary energy storage, including grid -scale energy storage, thanks to their high power performance, flexible design, and ease of scaling-up. The flow-based electrochemical energy storage systems utilize the appropriate electroactive species dissolved in externally flowing electrolytes which are ready to accumulate all (or part) of the charge. Among important issues is the search for highly efficient (i.e., capable of fast electron transfers) electroactive systems that would yield high power and energy densities during the systems' operation.

In the present work, we concentrate on utilization of highly concentrated iodine/iodide redox systems and their possibility to exhibit high rates of charge propagation. In practical terms, it can be combined with ZnI_2, or other zinc salt, containing electrolyte. Reactions in the zinc/iodine (polyiodide) redox flow battery are as follows: $Zn \rightarrow Zn^{2+} + 2e^-$ ($E = -0.76$ V vs SHE) at the negative electrode (anode), and $3I^- \rightarrow I_3^- + 2e^-$ ($E = 0.54$ V vs SHE) at the positive electrode (cathode) thus yielding a total theoretical potential output as high as ~1.3 V. The increase of current density could be achieved not only by reducing the viscosity of the electrolyte, thus accelerating charge-carrier transport, but also – by referencing to my experience with the iodine/iodide couple as charge relay for dye-sensitized solar cells – through improvement of the dynamics of charge propagation in highly concentrated iodine/iodide solution via the catalyzed enhancement of rates of electron self-exchange (hopping) between iodine/ iodide (polyiodide) redox species as well as by accelerating the interfacial kinetics at electrodes. This can be realized by choosing appropriate electrode materials and through their activation or modification. The electrochemical activities of the redox couples are usually significantly increased through application of nanostructured functionalized carbons. While dispersed in solutions they can improve electron transfers to the redox sites. The proposed chemistry has been first tested using the microelectrode methodology to determine mass-transport (effectively diffusional) coefficients for charge propagation, heterogeneous and homogeneous (electron self-exchange) rates of electron transfers. Unless catalyzed, both interfacial and bulk (self-exchange) electron transfers involving the iodine/iodide redox system are somewhat complicated; there is a need to break the I-I bond in the I_3^-or I_2 molecule; it has also been well-established that platinum (e.g. when deposited on the counter electrode) induces electron transfers within the iodine/iodide redox system. In the presentation, we are going to explore the respective interfacial (electrocatalytic) phenomena on nanostructured metal oxides (e.g. zirconia), in addition to traces of expensive platinum or palladium nanoparticles (provided that catalytic centers are three-dimensionally distributed in the electrolyte phase), and we will utilize them to enhance iodine/iodide electron transfers to develop a new generation of redox mediators or ultra-fast components of redox electrolytes. Our results show that the catalyzed iodine/iodide system can reach extremely high electron self-exchange rates, namely on the level of $10^9 – 10^{10}$ mol^{-1} dm^3 s^{-1}.

Nanoencapsulation of Phase Change Materials for Polymer Coatings with Heat Storage Capacity

Luis Fernando Jiménez-Hernández, Inés Adam-Cervera, Mario Culebras, Clara M. Gómez, Rafael Muñoz-Espí

Institute of Materials Science, University of Valencia, Carrer del Catedrátic José Beltrán Martinez 2, 46980 Paterna, Valencia, Spain
E-mail: rafael.munoz@uv.es

Keyword: Heat storage, Phase change materials, Nanoencapsulation, Miniemulsion polymerization.

Phase change materials (PCMs) offer a promising solution to address the intermittency of heat as a renewable source of energy [1–3]. The integration of encapsulated PCMs (ePCMs) into construction materials, such as glass coatings, aims to reduce the energy demand of buildings by regulating indoor temperatures [2, 3]. The thermoregulation capability of PCMs arises from their ability to absorb heat during phase transitions. Among different types, solid–liquid PCMs are particularly favored due to their high latent heat and minimal volume changes [1, 2]. However, encapsulation is necessary to prevent leakage and undesirable interactions with the environment. Reducing the capsule size to the nanoscale facilitates the integration of PCMs into modern building technologies without compromising functionality while also enabling control over phase transition kinetics.

In this study, we present different miniemulsion approaches for encapsulating organic PCMs within poly(styrene), poly(urethane), lignin, and chitosan nanocapsules. Furthermore, we evaluate the potential use of nanoencapsulated PCMs as fillers in thermoregulating coatings. The encapsulation process involved mixing the PCM with the shell precursors, followed by dispersion in an aqueous phase and the subsequent shell formation through either chemical or physical mechanisms. Polymer coatings were prepared casting and solvent evaporation from polymer solutions containing dispersed nanocapsules.

Electron Microscopy and Dynamic Ligth Scattering were used to study the morphology of the studied systems, exhibiting a narrowed size distribution with an average of 250 and 90 nm for lignin and chitosan nanocapsules respectively. The thermal events in the Differential Scanning Calorimetry thermograms were associated with the phase transitions (melting and crystallization) of the PCM, demonstrating their successful incorporation within the polymer nanoparticles. The thermogravimetric analysis shown an encapsulation efficiency above 90%. The phase transition enthalpy, related to the thermoregulating capacity of the nanoparticles, was found to be stable over several thermal cycles, therefore justifying further application studies. As a proof of concept, the biobased nanocapsules were incorporated into appropriate substrates for the later characterization of their thermoregulation capacity. In a typical assay, the loaded substates were evaluated by comparing the temperature difference between two compartments of a semi-adiabatic chamber under controlled heating conditions. It was observed that the apparent thermal diffusivity, relative to the pristine substrate, increased after the incorporation of the nanoencapsulated PCMs during the heating cycles.

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Investigation of metal oxide with native vacances as efficient electron-collecting transparent electrode active photovoltaic layers

Aleksandra Tomaszowska*[1], Paulina Powroźnik[1], Fabrizio Mo[2], Mariagrazia Graziano[2], Gianluca Piccinini[2], and Maciej Krzywiecki*[1]

[1] Institute of Physics – CSE, Silesian University of Technology, Konarskiego 22B, 44-100 Gliwice, Poland.
[2] Department of Electronics and Telecommunications of Politecnico di Torino, Corso Castelfidardo, 39, 10129 Torino, Italy
E-mails: aleksandra.tomaszowska@polsl.pl, maciej.krzywiecki@polsl.pl

Keywords: Energy level alignment, inorganic-organic structure, phthalocyanines, PVD, XPS, UPS, DFT

Inorganic-organic heterojunctions exhibit promising properties for various applications, including sensors, light-emitting diodes, and photovoltaic devices. One of the key factors influencing device performance and efficiency is the charge transfer between the metal electrode and the organic layer, which strongly depends on the alignment of their energy levels. Properly tuned energy barriers facilitate charge carrier transport across the interface, enhancing charge injection or extraction. A deliberate selection of materials that enables the elimination of additional interfacial alignment layers can simplify the fabrication process while simultaneously improving device performance.

While current photovoltaic research often emphasizes inverted structures due to their enhanced environmental stability, standard architectures—where a transparent conductive oxide serves as the anode—remain highly relevant. They offer valuable opportunities for interfacial energy engineering at the metal-organic contact - without the intermediary layers.

Metal oxide-based materials are extensively studied due to the wide range of available fabrication methods and their broad applicability in materials engineering and related fields. Thin films can be deposited via various methods, including wet-chemical techniques widely used in industry, particularly for optical and electronic applications. These approaches offer significant potential for structural modification of the resulting layers, making them attractive for advanced functional materials. Among electron-transporting oxides, tin dioxide (SnO_2) is especially promising, owing to its high electron mobility, low temperature processability (<500 °C), and tunable properties via doping. While most studies focus on doping-induced defect engineering to enhance carrier concentration and reduce resistivity, native defects remain underexplored despite their potential to significantly influence the electronic structure.

In this work, we present the complexes of inorganic-organic based on phthalocyanine, which were evaporated by the physical vapor deposition method on the defective tin dioxide layer fabricated by spin coating method. Additionally, surface-sensitive techniques (X-ray and ultraviolet photoelectron spectroscopy) were conducted to obtain core level positioning, chemical composition and also valance level localization.

To theoretically justify the selection of phthalocyanine compounds, quantum chemical calculations were performed to determine the density of states (DOS) and initial electron properties. The simulations were carried out using Density Functional Theory (DFT) as implemented in the Quantum ATK software, enabling accurate and computationally efficient analysis.

Based on the obtained data, a comprehensive band structure representation of the full system was constructed.

Investigation on thermoelectric properties of In-doped n-type $Bi_{1.5}Sb_{0.5}Te_3$ alloy

Ashok Rao[a*], P Aswinkumar[a], Poojitha G[a],

[a] *Department of Physics, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, 576104, India.*
**E-mail: a.rao@manipal.edu*

This study explores the influence of indium doping on the thermoelectric properties of the $Bi_{1.5}Sb_{0.5}Te_3$ alloy. Samples of $Bi_{1.5-x}In_xSb_{0.5}Te_3$ ($0 \le x \le 0.08$) were prepared by the solid-state reaction method, with homogeneous, dense compounds in a rhombohedral crystal structure confirmed by XRD analysis. Thermoelectric properties are measured over a low-temperature range from 10 to 350 K. The electrical resistivity shows metallic behaviour at lower temperatures and semiconducting behaviour at higher temperatures because of the thermal energy activation of charge carriers. A negative Seebeck coefficient across all samples indicates that electrons are the dominant charge carriers. The Seebeck coefficient decreases with indium doping, with the highest value of 110 µV/K observed at 350 K for the pure sample. This decrease in the Seebeck coefficient and increase in electrical resistivity results in a reduced power factor with doping. With the increase in doping, the thermal conductivity decreases due to the scattering of phonons from defects caused by dopant and decreased electronic thermal conductivity resulting from increased electrical resistivity. The minimum thermal conductivity of 16.2 mW/cm-K was found for the x = 0.08 sample at 350 K. However, the overall figure of merit (ZT) decreases with doping, with the highest ZT value of 0.02 observed for the undoped sample at 350 K.

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Phosphorus-Doped Ni–Co/Graphene Electrocatalysts for Bifunctional Energy Conversion: A Combined Experimental and Theoretical Study

Saleem Sidra, Hoa Van Hien, Do Hwan Kim

Department of Chemistry Education and Institute of Fusion Science, Graduate School of Department of Energy Storage / Conversion Engineering, Jeonbuk National University, 54896 Jeonju, Republic of Korea

E-mail: dhk201@jbnu.ac.kr

Keyword: Water splitting, Electrocatalyst, d-band center.

Green hydrogen is essential for driving forward renewable energy technologies and mitigating environmental impact. In this study, we present a controllable synthesis strategy for fabricating bimetallic nickel –cobalt phosphide anchored on reduced graphene oxide supported by nickel foam ($NiCo_3P \cdot C/NF$). The resulting material exhibited remarkably low overpotentials of 58 mV for the hydrogen evolution reaction (HER) and 180 mV for the oxygen evolution reaction (OER) at a current density of 10 mA cm^{-2} in 1.0 M KOH. The electrocatalyst demonstrated excellent overall water-splitting performance, requiring operating voltages of 1.54 V and 2.6 V at current densities of 10 and 500 mA cm^{-2}, respectively. Notably, $NiCo_3P \cdot C/NF$ maintained 98% of its initial efficiency after 75 hours of continuous operation at 53 mA cm^{-2}, outperforming both Pt/C + RuO_2benchmark samples and previously reported catalysts. To elucidate the origin of this high performance, density functional theory (DFT) calculations were performed. The results revealed a synergistic interaction within the $NiCo_3P \cdot C$ structure, with a nearly zero Gibbs free energy change for hydrogen adsorption and an upshifted d-band center at the Ni active site for HER. For OER, the P active site exhibited the lowest overpotential of 0.26 V. Charge density analysis showed maximum electron accumulation at the heterojunction between the $NiCo_3P$ phase and graphene sheet, contributing to enhanced electrical conductivity. This integrated experimental and theoretical study offers a promising strategy for the rational design of sustainable, high-performance electrocatalysts for water splitting and green hydrogen production.

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A Scale-up Synthesis of Porous Silicon Particles: Reduction Conditions versus Properties on the Li-Battery Anode Performances

JeongWoo Bae and Jung Kyoo Lee*

Department of Chemical Engineering (BK21 FOUR graduate program), Dong-A University, Busan 49315, Republic of Korea

E-mail: jklee88@dau.ac.kr

Keyword: Lithium Batteries, Solid-State Batteries, Anodes, Porous silicon, Scale-up synthesis, Rotary Magnesiothermic Reduction.

A 1L-scale dynamic magnesiothermic reduction (DMR) of solid silica (1.8 ㎛ in diameter) was conducted using a rotary reactor system to produce porous silicon (pSi) particles for lithium ion battery (LIB) and all-solid-state battery (ASSB) anodes. The effects of the heat scavenger (NaCl) to silica ratio (NaCl/silica weight ratio = 0.8, 3.0, 5.0, and 10.0) were systematically studied and analyzed with respect to; (i) the exothermic reduction heats (monitored *in situ*), (ii) the porosity of pSi particles, and (iii) the electrochemical performance of the resulting pSi/C composites in comparison with conventional silicon nanoparticles (SiNP, <50 nm)/C as LIB and all-solid-state-battery (ASSB) anodes. When the NaCl/silica weight ratio was ^{3}5, no temperature spikes were detected due to efficient exothermic heat dissipation, and highly porous pSi particles were produced. Thanks to their structural advantages, both bare pSi particles and the pSi/C composite exhibited superior cycling performance compared to bare SiNP and SiNP/C as LIB anodes, respectively. Notably, The pSi/C composite achieved excellent capacity retention, maintaining over 90.9% for 270 cycles at a current density of 500 mA g^{-1}, along with appreciable rate capability and minimal electrode thickness variation. It also demonstrated appreciable performances as ASSB anodes. Thus, the DMR of silica presented a scalable mass-production technology for the commercial scale manufacturing of porous silicon particles, as promising anode materials for high-performance LIBs and ASSBs.

Design, Spectral Characterization, and Photophysical Analysis of a Hydroxy-Substituted Chalcone Derivative

Vasavi[1] Deepika D.[1] J. N. Cheerlin Mishma[2] Prinston Melroy Lewis[3] Suresh D. Kulkarni[3], Santosh L. Gaonkar[1*]

[1]*Department of Chemistry, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, 576104, Karnataka, India*
[2]*Department of Physics, Women's Christian College, Nagercoil, Tamil Nadu, INDIA.*
[3]*Department of Atomic and Molecular Physics, MIT Campus, Manipal Academy of Higher Education, Manipal, Karnataka 576104, India.*
E-mail: *sl.gaonkar@manipal.edu*

Keyword: Chalcones, Fluorescence, Photophysical studies, DFT

Chalcones are a class of biologically active compounds known for their diverse pharmaceutical and therapeutic applications. Owing to their extended π-conjugation, chalcones also exhibit notable fluorescence, making them promising candidates for applications in sensing, bioimaging, and optoelectronic devices. In the present study, we report the synthesis of the chalcone derivative (E)-3-(2-hydroxyphenyl)-1-(4-hydroxyphenyl)prop-2-en-1-one. The structure of the synthesized compound was confirmed through spectroscopic techniques including FT-IR, UV–Vis, ^{1}H NMR, and ^{13}C NMR analyses. Photoluminescence measurements revealed an emission peak at 605 nm, corresponding to the red region of the visible spectrum. Furthermore, density functional theory (DFT) calculations were performed to obtain the optimized molecular geometry and to explore the electronic properties such as frontier molecular orbitals (FMO), UV absorption behavior, molecular electrostatic potential (MEP) distribution, and first-order hyperpolarizability. These combined experimental and theoretical insights underscore the potential of this chalcone derivative in photonic and optoelectronic applications.

Unlocking Potential: Iodide-Doped Nickel-Boosted MXene Composite for High-Performance Sodium-Ion Hybrid Capacitors

Sudhakar Y N[a], Nakul Desai[b]

[a] *Department of Chemistry, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, Karnataka, India*
[b]*Manipal Technologies Limited, Manipal, Karnataka, India.*
E-mail: sud5re@gmail.com

Keyword: MXene-based electrodes, iodine doping, sodium ion hybrid capacitor

2D MXenes have gained significant attention for energy storage applications, particularly in hybrid capacitors, due to their excellent electrochemical properties. Among them, sodium-ion hybrid capacitors (SIHCs) have shown promising performance. However, challenges such as morphology distortion and rapid capacity fading hinder their long-term stability. To address these issues, researchers have explored MXene-based composites. In this study, we present a novel sodium iodide and nickel-decorated MXene composite (Ti_2C/Ni/NaI) as an electrode material for SIHCs. The Ti_2C MXene and Ni contribute to structural stability and mechanical strength, while iodine enhances redox activity. Structural analysis revealed a rough surface with aggregated 2D MXene sheets uniformly coated with Ni, Na, and I atoms. Raman spectroscopy and XPS confirmed the successful incorporation of dopants into the MXene framework. The assembled hybrid capacitor demonstrated excellent cycling stability, retaining 59% of its capacity after 10,000 cycles at 0.5 mA g^{-1}. These results highlight the Ti_2C/Ni/NaI composite as a promising electrode material for high-performance sodium-ion hybrid capacitors.

Session: Synthesis and Characterization of Nanomaterials

Invited Lectures

Regular Lectures

Poster Presentations

Stimuli-degradable Polymer Particles for Triggered Drug Release

D. Kuckling[a], K. Völlmecke[a], O. Dückmann[a], M. van der Linde[a],
T. Rust[a], D. Jung[a] and K. Langer[b]

[a] *Department of Chemistry, Paderborn University, Warburger Str. 100, 33098 Paderborn, Germany*
[b] *Institute of Pharmaceutical Technology and Biopharmacy, University of Münster, Correnstr. 48, D-48149 Münster, Germany*

E-Mail: dirk.kuckling@uni-paderborn.de

Keyword: stimuli responsive, drug delivery, degradable polymers

For an effective pharmacotherapy an optimal accumulation of a drug within an affected part of the body is required. Furthermore, a controlled release of the drug at the target site is required. This can be realized by "intelligent" systems utilizing different triggers like light, pH value or redox properties to release the drug in a controlled fashion. Colloidal drug delivery systems based on novel switchable polymers are investigated allowing an effective drug transport into cells and tissues. On one side the intracellular pH shift in endolysosomal compartments is used to effectively degrade the polymer and release the drug. Furthermore, the increased concentration of reductive glutathione (GSH), which especially can be found in tumour cells, is used for the degradation of redox-sensitive polymers. In a well reproducible fashion, e.g. dithiothreitol (DTT) was polymerized using 2,2'-dipyridyl disulfide (DPD) as an oxidant that at the same time serves as the end-cap. Nanoparticles were prepared by the nano-precipitation method yielding particles with a z-average diameter of ca. 240 nm and a PdI of 0.2. To show the applicability as degradable nanoparticles in biomedical applications, particle stability was tested at 37 °C in PBS buffer with added reductants DTT and GSH at biologically relevant concentrations (1-0.1 mM). The particles showed a decrease in count rate upon the trigger, which relates to a degradation of the particle. Additionally, light switchable polymers are investigated that can release the embedded drug from the drug carrier after a short period of irradiation.' The final goal is the development of drug delivery systems being able to respond to different stimuli.

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Endocrine disrupting activity of complex mixtures with plastic nanoparticles

Ivana Vinković Vrček[1], Lucija Božičević[1], Nikolina Peranić[1], Korinna Altmann[2], Jana Hildebrandt[2], Raquel Portela[3], Miguel Banares[3]

[1]*Institute for Medical Research and Occupational Health, Ksaverska cesta 2, 10000, Zagreb, Croatia*
[2]*Bundesanstalt für Materialforschung und -prüfung, Unter den Eichen 87, 12205 Berlin, Germany*
[3]*Institute for Catalysis and Petrochemistry, CSIC, C. de Marie Curie 2, E-28049, Cantoblanco, Madrid, Spain*

The large-scale production of plastic items, their endurance and inadequate recycling practices cause massive plastic pollution [1]. Degradation of larger plastic items through mechanical, biological, or chemical processes can lead to the formation of nanoplastics, particles characterized by small size and large surface area. Due to those properties, nanoplastics can penetrate different biological barriers, posing potential risk for different organisms. In addition, endocrine disrupting chemicals including paraben (PAR) and oxybenzone (OXY) are also considered as emerging pollutants, frequently detected in the environment at concentrations up to µg/L. PNPs can adsorb these drugs acting as "Trojan horse" for their bioaccumulation and biodistribution. As toxicity of such mixtures is still unknown, this study aimed to elucidate endocrine disrupting effects of different PNPs, PAR, OXY and their mixtures.

Experiments were performed using cell line HeLa-9903, designed to assess the effects of various chemicals on the estrogen receptor (ER) activity according to the OECD test guideline No. 455 [2]. To explore the influence of polymer type and nanoparticle size on their ability to interact with ER, we used 4 different polymers and 5 different sizes. Polystyrene nanoparticles (PSNPs, 50 nm, 150 nm, 350 nm), polyethylene nanoparticles (PENPs, 50 nm, 350 nm), polypropylene nanoparticles (PPNPs, 50 nm, 180 nm) and polyethylene terephthalate nanoparticles (PETNPs, 80 nm) were included in this research. Four different PNPs mixtures were evaluated: MIX50 (PSNPs 50 nm, PENPs 50 nm, PPNPs 50 nm and PET), MIX150 (PSNPs 150 nm and PPNPs 180 nm), MIX350 (PSNPs 350 nm and PENPs 350 nm) and MIXPS (PSNPs 50 nm, 150 nm and 350 nm). In addition, PNP mixtures either with PAR or with OXY were additionally evaluated.

Results showed that PENPs (350 nm) and PPNPs (180 nm) individually act as ER agonists. All observed effects were more pronounced when the cells were treated with complex mixtures. Observed results highlight the importance of mixture toxicity inclusion in risk assessment.

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Revolutionizing materials engineering and processing with microfluidic tools

Josep Puigmartí-Luis [a,b]

[a] *Departament de Ciència dels Materials i Química Física, Institut de Química Teòrica i Computacional, 08028 Barcelona, Spain.*
[b] *Institució Catalana de Recerca i Estudis Avançats (ICREA), Pg. Lluís Companys 23, 08010 Barcelona, Spain.*
E-mail: josep.puigmarti@ub.edu

Keyword: Microfluidic technologies, self-assembly, supramolecular materials, crystallization, materials engineering

Controlling and understanding the mechanisms that govern crystallization processes is crucial in contemporary materials science, particularly in the field of reticular solids, where significant challenges remain. In this seminar, I will demonstrate how microfluidic synthetic conditions can control the size and shape of various functional porous crystals, such as metal-organic frameworks (MOFs) and covalent-organic frameworks (COFs). Specifically, I will show that microfluidic synthesis can produce the largest MOF single crystals with controlled nonequilibrium shapes reported to date, in contrast to the typical polyhedral microcrystals formed under bulk crystallization conditions. Additionally, I will illustrate how microfluidic technologies can address several challenges in the COF research area. For instance, I will demonstrate that a microfluidic device can enhance the processability of COFs, enabling the creation of macroscopic architectures composed solely of COFs with arbitrary shapes. This is particularly significant given that COFs are typically obtained as powders with limited solubility and no melting point, making conventional processing techniques like solution processing or melt-extrusion inapplicable, which also hinders their use in many potential applications. Moreover, I will also present how our group utilizes microrobotic platforms to apply MOFs and COFs in biotechnology and other advanced fields. These microrobotic systems enable precise 3D manipulation of MOFs and COFs, facilitating innovative appli-cations such as targeted drug delivery, biosensing, and tissue engineering. By integrating microrobotics with our advanced synthesis techniques, we can create highly specialized and functional materials tailored for specific biomedical applications. This approach not only enhances the versatility and functionality of MOFs and COFs but also opens new avenues for their use in cutting-edge biotechnological solutions.

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In-situ nanoscale characterization of strains and microstructure in thin films

Jozef Keckes[a], Juraj Todt[a], Michael Meindlhumer[a], Manfread Burghammer[b],

[a] *Montanuniversität Leoben, Jahnstrasse 12, 8700 Leoben, Austria*
[b] *European Synchrotron Radiateion Facility, Grenoble, France*
E-mail: jozef.keckes@unileoben.ac.at

Keyword: Thin films, X-ray nanodiffraction, Synchrotron,

Thin films possess complex gradients of residual strains and stresses, which vary laterally and also across film thickness. These originate (i) from self-organized film growth, (ii) from intentionally varying deposition conditions and/or (iii) from inhomogeneous thermal and/or mechanical loads applied during service. In order to reveal those gradients and subsequently optimize functional properties of thin films, it is necessary to apply nanoscale characterization approaches.

Cross-sectional synchrotron X-ray nanodiffraction (CSnanoXRD) [1] using monochromatic X-ray beams with a diameter down to ~30 nm provides representative depth-resolved data on the evolution of phases, crystallographic texture, grain morphology and strains/stresses across thin film cross-sections. The aim of this contribution is to discuss methodological and instrumental aspects of the approach as well as to present recent achievements from experiments at the beamlines ID13 of ESRF. By the examples of hard nitride, diamond and metallic thin films, it will be demonstrated that the approach can serve as an effective tool to characterize the inhomogeneous properties of as-deposited and in-situ mechanically-loaded films. The observed gradients can be correlated with the varying film deposition conditions, providing an opportunity to optimize the time-dependent synthesis process and perform knowledge-based design of the nanocrystalline thin films. Finally, an outlook, especially on in-situ experiments as well as an analysis of complex depth gradients of structure-property relationships in nanocrystalline thin films, performed with even smaller X-ray beams, will be discussed.

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Experimental and theoretical aspects of CCVD synthesis of vertically aligned carbon nanotubes

Lilla Nánai[a], George Kaptay[a,b], Klara Hernadi[a]

[a] *Laboratory of Applied Nanomaterials; Institute of Physical Metallurgy, Metal Forming and Nanotechnology; University of Miskolc; 3515 Miskolc-Egyetemváros, C/2-5 Building 209, Hungary*
[b]*MTA-ME Materials Science Research Group, Miskolc-Egyetemvaros, 3515, Hungary*
E-mail: klara.hernadi@uni-miskolc.hu

Keyword: Vertically aligned carbon nanotubes; Substrates with thin catalyst layers; Catalytic chemical vapor deposition; CNT growth mechanism

Carbon-based materials have been essential to mankind since prehistoric times; but the last hundred years have seen major breakthroughs in the discovery and use of new forms of carbon. It is not possible to assess which form of carbon is most significant for science and technology today, but it is worth making a brief comparison.

Since the 1990s, carbon nanotubes have been the focus of continuous attention of the research community due to their outstanding chemical, physical and electrical properties. Vertically aligned carbon nanotubes can play an important role in electrical, mechanical developments and as additives in composites.

Efficient and reproducible growth of vertically aligned carbon nanotube (VACNT) forests by catalytic chemical vapor deposition (CCVD) requires well-defined settings of the catalyst layer structure and CCVD conditions. In addition to the experimental approach, we have aimed to gain a deeper understanding of the catalyst layer behaviour and the synthesis processes under the reaction conditions used, and have therefore supported our results with theoretical considerations.

The growth mechanism of carbon nanotubes is still a controversial topic, as it involves processes such as dissociation of the carbon source and diffusion of carbon through or across the catalyst nanoparticles. The experimental observations showed very good consistency with the step-by-step theoretical considerations, confirming the validity of the hypotheses.

Acknowledgments

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Synthesis and Characterization of Polyurethane/POSS Hybrid Nanomaterials

Krzysztof Pielichowski

Department of Chemistry and Technology of Polymers, Cracow University of Technology, Krakow, Poland
E-mail: kpielich@pk.edu.pl

Keywords: polyurethane, NIPU, POSS, hybrid materials, nanocomposites, thermal analysis, thermal properties

Polyurethanes (PU) are a significant and versatile class of polymers extensively used as both everyday products and in numerous industrial applications. They are synthesized in the polyaddition reaction of diisocyanates and diols, leading to formation of urethane linkages formed as a result of the reaction of isocyanate and hydroxyl groups. In thermoplastic polyurethanes, the polymer structure comprises of soft segments - typically derived from long-chain polyols - and hard segments, which are formed through the reaction of diisocyanates with low molecular weight diols, commonly referred to as chain extenders. The inherent thermodynamic incompatibility between the flexible (soft) and rigid (hard) segments leads to a phase-separated morphology characterized by microdomains enriched with hard segments dispersed within a soft, continuous phase. Despite beneficial properties of polyurethanes, they are characterized by limited thermal stability and are flammable, so numerous research efforts are dedicated to improve these properties. One of the promising approaches is the development of hybrid polymer systems incorporating nanostructured fillers - polyhedral oligomeric silsesquioxanes (POSS). POSS are organo-silicon chemical compounds with the formula $(RSiO1,5)n$, where n = 6-18, and R is a hydrogen atom or an organofunctional non-reactive or reactive substituent (alkyl or aryl groups). Depending on the nature of the functional groups present, they provide interactions with the continuous polymer phase and could be chemically incorporated into the polyurethane structure forming thus organic-inorganic hybrid material with unique architecture, or physically mixed to fabricate nanocomposites [1]. As a result of the works carried out so far, it was found that the incorporation of thermally stable POSS particles into the PU matrix changes polymer thermal properties; specifically, POSS addition can alter the glass transition temperature (Tg), improve thermal stability, and suppress molecular mobility through steric hindrance or crystalline domain formation [2,3]. Such effects have also been explored in non-isocyanate polyurethanes (NIPUs), obtained in the reaction of diamines with difunctional cyclic carbonates, modified by POSS moieties. Importantly, in the NIPUs synthesis there is no need to use toxic isocyanates [4]. Furthermore, polyurethane/POSS hybrids were found to show notable reductions in flammability and heat release rates during combustion, underscoring their potential as advanced materials for fire-safe and thermally resilient applications.

In this lecture synthesis, characterization and thermal properties of PU/POSS and NIPU/POSS hybrid materials and nanocomposites, obtained as elastomers or foams, will be discussed.

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Band structure and electrochemistry of semiconducting oxides for energy applications

Ladislav Kavan

J. Heyrovsky Institute of Physical Chemistry of the Czech Academy of Sciences, Dolejskova 2155/3, 182 00 Prague 8, Czech Republic
E-mail: kavan@jh-inst.cas.cz

Keywords: Semiconducting oxides ; electronic structure; work function ; batteries ; energy conversion and storage

Experimental and theoretical studies in the field of energy conversion and storage have primarily focused at lithium or post-lithium batteries, solar fuels and photovoltaics. Optimizing these technologies requires detailed information about the electronic structure near the conduction band minimum (CBM), which can be quantified by the work function, among other factors [1]. However, analyzing the CBM structure is challenging and sometimes fundamentally impossible [2]. Investigations spanning various materials, from macroscopic single crystals with different face orientations to polycrystalline and quasi-amorphous thin films on various substrates, in both aqueous and aprotic electrolyte solutions, have provided self-consistent data while also revealing some issues. Notable challenges include: (i) Determining flatband potentials and donor concentrations using Mott-Schottky analysis, particularly for nanotextured materials. There is a significant spread in flatband potentials for various oxides and overestimated concentrations of majority charge carriers, which could lead to incorrect predictions of degenerate semiconductors; (ii) Calculating work functions and band edges via DFT, often neglecting the effects of sample environment and/or defects in real crystals; (iii) Measuring work functions and band edges using only a single experimental technique (e.g., photoelectron spectroscopy, Kelvin probe, or electrochemistry), despite the inherently poor reproducibility of values from each individual method; (iv) Transposing these problematic theoretical and experimental data into discussions on water splitting, solar fuel generation, solar cells, and lithium-ion batteries [3, 4].

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Fluorescent nitrogen-doped carbon quantum dots with similar optical properties yet different origins

Lenka Zajíčková[a,b], A. Mukherjee[a], D. Nečas[a], J. Gómez[c], L. Janů[a], N. Pidzúrová[d]

[a] *CEITEC, Brno University of Technology, Czechia*
[b] *Dept Condensed Matter Physics, Masaryk University, Brno, Czechia*
[c] *Centro Interdisciplinar de Química e Bioloxía (CICA), Universidade da Coruña, Spain*
[d] *Institute of Physics of Materials, Czech Academy of Sciences, IBrno, Czechia*
E-mail: lenkaz@physics.muni.cz

Keyword: Carbon nanoparticles; Photoluminescence

Carbon quantum dots (CQDs), fluorescent quasi-spherical nanoparticles with crystalline graphitic core [1], can be synthesized by many methods. Their optical properties were explained by the band gap governed by the size of the sp^2-domain (the extent of the π-electron system) [2,3] and surface defects controlled by edge configuration and functional groups, such as hydroxyl, amide, carbonyl, and carboxyl moieties [3,4]. However, the optical properties of solvothermal-synthesized CDs could also be affected by the presence of unreacted species or small organic molecules [5], and the intense excitation-independent photoluminescence (PL) of CDs was indeed attributed to molecular fluorophores, which may be surface-bound or embedded in the CD matrix [6].

Previously, we prepared the nitrogen-doped CQDs (N-CQDs) from glucose and ethylenediamine using a one-step and fast (a few minutes) microwave-assisted hydrothermal synthesis [7]. The average size of the particles was 3.8 nm, and high-resolution TEM confirmed their crystalline graphitic nature. The carbon structure contained 18.6 at.% of nitrogen and 12.6 at.% of oxygen. Later, we observed the spontaneous room-temperature formation of N-CQDs from the same reactants, glucose and ethylenediamine. After 5 months, the spontaneously formed N-CQDs exhibited similar structural properties, optical absorption in the UV-VIS range, and PL emission as those synthesized in the microwave reactor [8].

In this work, we will compare the optical properties of the two above-mentioned N-CQDs with the nanoparticles obtained from plasma-deposited amorphous organic thin films with amino groups. Thanks to these films' partial water solubility, the presence of fluorescent nanoparticles was detected as the fluorescence of water extracts. High-resolution transmission electron microscopy proved that the nanoparticles are graphitic, and their PL spectra also exhibited excitation-dependent emission.

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Plasmon-enhanced Raman spectroscopy for sensing applications

Luca Guerrini

Department of Physical and Inorganic Chemistry. Universitat Rovira i Virgili, Carrer de Marcel·lí Domingo 1, 43007 Tarragona, Spain. Email : luca.guerrini@urv.cat

Keywords : Nanomaterials, Plasmonics, Raman, Sensing

Nanomaterials have become central to the development of innovative analytical strategies, particularly in the fields of biosensing and environmental monitoring. Among the most promising advances are plasmonic optical biosensors, which offer significant advantages over conventional analytical methods.

In this context of plasmon-enhanced spectroscopies, surface-enhanced Raman scattering (SERS) has emerged as a powerful technique for the rapid, cost-effective, ultrasensitive, and multiplexed detection of (bio)molecules.[1–3] SERS uniquely combines Raman spectroscopy molecular specificity and experimental versatility with the exceptional signal enhancement of plasmonic nanostructures.

Notably, continuous advances in nanofabrication methods and the ongoing evolution of spectroscopic instrumentation are facilitating the transition of SERS from a predominantly academic technique to a commercially viable and field-deployable technology.[4–6]

This presentation aims to provide an accessible overview of the fundamental principles of SERS, along with representative examples of its application in biosensing and environmental analysis, highlighting its potential for practical impact.

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Tailoring functional nanomaterials for sustainable solutions to complex energy and environmental challenges

Maria Lucia Curri,

Department of Chemistry University of Bari, via Orabona 4, 70126 Bari, Italy
Italian National Research Council CNR IPCF, via Orabona 4, 70126 Bari, Italy
National Interuniversity Consortium of Materials Science and Technology INSTM, Bari Research Unit

E-mail: marialucia.curri@uniba.it

Keyword: Soft chemistry, Nanostructures, Energy and environmental applications, Scalability

Recent advancements in soft chemistry have opened new avenues for the precise design and functionalization of colloidal inorganic nanoparticles (NPs) and nanocrystals (NCs), enabling fine control over their size, shape, and surface properties. These structural features critically influence their electronic, optical, and catalytic behaviors, making them ideal candidates for cutting-edge applications in energy and environmental fields [1]. Targeted surface modifications further enable these nanostructures to interact selectively with their surroundings, significantly enhancing their performance and versatility.

This presentation will highlight recent progress in scalable soft-chemistry strategies for fabricating hybrid materials and complex nanostructures. Special emphasis will be placed on nanocomposites exhibiting emergent functionalities that arise from the synergistic integration of diverse nanoscale components. These advanced materials show exceptional promise in areas such as photovoltaics, energy storage, environmental photocatalysis, and antimicrobial technologies—offering innovative and sustainable solutions to some of today's most pressing global challenges [2-4].

Looking forward, this work outlines promising pathways to address the challenges of scaling soft-chemistry methods for industrial production. By refining manufacturing techniques, optimizing reaction parameters, and implementing innovative process designs, it becomes possible to preserve structural integrity and reproducibility while fully harnessing the unique size-dependent properties of nanomaterials. Such advances are crucial to bridging laboratory innovation with real-world deployment in clean energy and environmental remediation.

The work has been supported by "Scalable Production of Advanced Nanostructures for Electrodes" SPARKLE (PNRR NEST - NETWORK 4 ENERGY SUSTAINABLE TRANSITION") project and by the Italian PRIN 2022 PNNR Project Hybrid ElectROchemical Energy storage in Sustainable batteries (HEROES - cod P2022AFYZX, 2023-2025).

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Ligand and environment dependence of the spontaneous and stimulated emission properties of fully inorganic perovskite nanocrystals

Marco Anni[a]

[a] *Dipartimento di Matematica e Fisica "Ennio De Giorgi", Università del Salento, Via per Arnesano, 73100 Lecce (Italy)*
E-mail: marco.anni@unisalento.it

Keyword: lead halide perovskites, optical gain, photoluminescence quantum yield, optical sensors

Over the past decade, fully inorganic perovskite nanocrystals (NCs) have been proven to be efficient active materials for optoelectronic applications. The photoluminescence and stability properties of these nanostructures are demonstrated to be highly dependent on the surface chemistry and, specifically, on the surfactant molecules used to passivate the surface defects. Here, we present a study of the dependence of the amplified spontaneous emission (ASE) properties of CsPbBr3 perovskite NC thin films, their photostability, and their sensitivity to ambient air on the NC capping ligand.
Four different samples have been analyzed, representatives of the three generations of capping ligands: oleic acid and oleylamine as the first generation, didodecyldimethylammonium bromide as the second generation, and 3-(*N*,*N*-dimethyloctadecylammonio)- propanesulfonate (ASC18) and lecithin as the third generation. We discuss the different properties of quantum efficiency, optical gain, optical stability, and atmospheric sensing of NCs as a function of the four different ligands employed, focusing on the chemical-physical processes underlying the observed differences. We then establish the structures that ensure the best performances among the four studied physical characteristics. Among all of them, lecithin-capped NCs show the best performances in terms of ASE threshold and sensing. Our results could lay the groundwork for determining the optimal synthesis and processing conditions for perovskite NCs as a function of their intended technological applications

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Why Turbulent Mixing Sucks (It's Not You)

Mario Palacios-Corella[a], Josep Puigmartí-Luis [a,b],

[a] *Department of Materials Science and Chemistry Physics & Institute of Theoretical and Computational Chemistry (IQTCUB), University of Barcelona, C/Martí I Franquès 1, 08028 Barcelona, Spain.*
[b] *ICREA. Passeig Lluis Companys, 23 E-08010 Barcelona, Spain.*
E-mail: mariopalacios@ub.edu

Keyword: microfluidics, spin-crossover, nanomaterials, fibers

Turbulent mixing has long served as a cornerstone in chemical synthesis due to its operational simplicity and scalability. However, its inherent limitations—such as uncontrolled precursor diffusion, poor spatial resolution, and the inability to access out-of-equilibrium reaction pathways—have driven a growing interest in more precise methodologies. In this oral communication, I will introduce a cutting-edge microfluidic strategy that addresses these challenges through the rational design of next-generation microfluidic chips, enabling full three-dimensional (3D) control over reaction–diffusion (RD) zones (**Figure 1**). This level of control unlocks new possibilities in the synthesis of functional materials, including layered double hydroxides (LDHs)[1], covalent organic frameworks (COFs)[2], and spin-crossover (SCO) materials [3], which display physicochemical properties—such as crystallinity, porosity, and magnetic behavior—unattainable by conventional methods. I will show how precise tuning of flow parameters, such as spatial flow positioning and flow rate ratios, permits on-demand customization of these properties. In particular, I will show the engineering of SCO materials with distinct magnetic behaviors through controlled modulation of polymorph ratios within their crystalline structures. These findings underscore the transformative potential of microfluidics not only as a synthetic platform but also as a foundational tool for advancing next-generation functional materials.

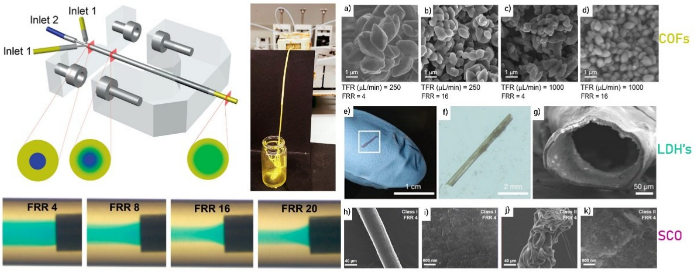

Figure 1: 3D control over RD zones enables the generation of materials with unprecedented physicochemical properties.

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Fuel nano additives produced from food waste to reduce aviation gas turbine carbon footprint and make sustainable aviation fuel suitable for air freight

Protima Rauwel[1], Md Shafiqul Islam[1], Glemarie Hermosa[2], Olga Pihl[3], Madis Parv[1], Neethu Xavier Akkara[1], Priyanka Panchal[2], Erwan Rauwel[2]

[1]Estonian Aviation Academy, Department of Aeronautical Engineering, Estonia.
[2]Estonian University of Life Science, Institute of Veterinary Medicine and Animal Science, Estonia.
[3]Oil Shale Competence Centre, Virumaa College, School of Engineering, Tallinn University of Technology, Estonia
E-mail: protima.rauwel@eava.ee

Keyword: Nano-additive, gas turbine engine, sustainable aviation fuel

Aviation-related emissions correspond to 3% of global greenhouse gas emissions. Sustainable aviation practices require reducing these emissions in order to reach Net Zero by 2050. In this regard, nanoparticle additives in jet fuel serve as a viable method to achieve these objectives. The use of sustainable aviation fuels (SAF) is gaining momentum, supported by aviation-related mandates. From 2025, SAF should constitute 2% of all aviation fuels in the EU. SAF is a blend of jet fuel and HEFA in variable proportions, but is currently limited to 50% HEFA. Increasing the proportion of HEFA can be achieved by using nanoparticle additives. To that end, nanoparticles of ZnO, graphene and graphitic carbon nitride (GCN) were synthesized from waste cooking oil and plant parts, respectively. The transformation of waste into nanopowders aligns with circular economy principles. These nanoparticles are added to jet fuels in varying proportions of 5 ppm, 10 ppm and 15 ppm, and the combustion in a TA-8 gas turbine motor was evaluated. Some engine parameters, including compressor pressure and exhaust temperature, show a decrease. In terms of emissions, the GCN additive suppresses NOx and CO production, in certain cases compared to pure Jet A-1 aviation fuel. The physicochemical properties of the fuel have also been tested in order to check their compliance with ASTM D1655 standards for Jet A-1.

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Carbon nanomaterials for electrochemical sensing

Rasa Pauliukaite[a,b], Ruta Aukstakojyte[b], Gintare Rimkute[b], Justina Gaidukevic[a,b], Pamela Rivera[a], Vytautas Zutautas[a], Aivaras Sartanavicius[c], Romualdas Trusovas[c]

[a] *Department of Nanoengineering, FTMC, Savanoriu ave. 231, Vilnius LT-02300, Lithuania*
[b] *Department of Inorganic Chemistry, Institute of Chemistry, Faculty of Chemistry and Geosciences, Vilnius University, Vilnius LT-03225, Lithuania*
[c] *Department of Laser Technology, FTMC, Savanoriu ave. 231, Vilnius LT-02300, Lithuania*
E-mail: rasa.pauliukaite@ftmc.lt

Keyword: Graphene, Electrochemical Sensors, Laser Induced Graphene, Dopamine, Trace Analysis

Electrochemical sensors are experiencing a renaissance because they are easier to miniaturize and integrate than other sensors. Carbonaceous materials are widely used in electrochemical sensors due to their wide potential window, which allows more analytes to be detected. Recently, the use of carbon nanomaterial modified electrodes has become more common for miniaturisation and integration as well as to reduce the cost of electrochemical sensors.

Reduced graphene oxide (rGO) doped with nitrogen heteroatom enhances electron transfer and is used as a material to modify electrodes for the development of electrochemical sensors. N-doping is performed by thermal synthesis of rGO in the presence of NH_3 [1] or Bismark brown dye [2]. Such electrodes are suitable for electrochemical (bio)sensing of glucose and hydrogen peroxide [1] or dopamine [2]. Sensitive and selective electrode for dopamine detection is also obtained using rGO and polypyrrole composite [3]. Another approach to assemble flexible sensors is the fabrication of laser induced graphene (LIG) on polyimide (PI) surface [4, 5]. Further modification of LIG with Bi or polymeric compounds is suitable for the development of electrochemical sensors for monitoring pH [4] and heavy metal ions [6].

Major challenges in the modification of electrodes with carbonaceous nanomaterials (N-doped rGO, nanocomposites and LIGs) will be discussed during the presentation. Also, peculiarities of electrochemical sensors for different analytes such as dopamine, pH, Zn(II), Cd(II) and Pb(II) ions will be presented.

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Functional metal oxides for gas sensing

Vincenzo Guidi[a], Danial Ahmed[a], Barbara Fabbri[a], Arianna Rossi[a], Emanuela Tavaglione[a]

[a]*Department of Physics and Earth Sciences, University of Ferrara, Via Saragat 1, 44122, Ferrara, Italy*
E-mail: vincenzo.guidi@unife.it

Keyword: Gas sensing, Functional materials, Nanostructured metal oxides.

The great expectations of the gas-sensor market have fostered research in material science and technology toward constant development. In particular, the search for materials should accomplish high sensitivity and low-power consumption. In the last years, a wide plethora of sensing materials has been developed, from traditional (e.g. ceramic thin/thick films) to nanostructured (e.g. nanowires, nanosheets, nanoflowers) semiconductors, including novel low-dimensional semiconductors (e.g. graphene, black phosphorus, metal organic frameworks).

The great challenge of low-dimensional nanostructured materials lies in the control of their properties by the morphology and the grain size, which combines bulk and surface effects. One-dimensional nanostructures are ideal for investigating the dependence of electrical transport, mechanical and optical properties on size and dimensionality. Two-dimensional nanostructures are ideal components for nanoscale devices, due to their high surface-to-volume ratio, fascinating photocatalytic and optical activities.

Indeed, most common conventional gas sensors are based on three-dimensional Metal Oxides (MOX). The sensing mechanism behind transduction is the chemo-resistive effect, is the build-up of a Schottky barrier at grain surface with formation of an energy barrier determining grain-to-grain current percolation. As the environment contain the target analyte, redox reactions take place at the surface of nanograins, modulating the current, i.e., transducing a gas concentration into an electrical signal.

These devices are low-cost and provide high sensitivity, but they suffer of poor stability over the time and need high power consumption to heat up the transducer for recovery, which restricts their use in portable sensing systems. The performance of MOX-based sensors depends crucially on their dimensions, morphology, composition, and surface activity. Among the several parameters that influence the sensing properties of a MOX sensor, the potential barrier at the interface between grains is a major physical quantity. In this sense, the broad assortment of one-, two- and three-dimensional MOX nanostructures has been a precious source for gas sensors technology, which owes its constant development to the requirements of physical, chemical and biological detection systems.

An important aspect of research is understanding the mechanism of chemical reaction occurring at surface. Such knowledge would be important in order to select the catalysts that foster wanted reaction with the analyte and hinder those with the interferants. An innovative method for this purpose, is FTIR spectroscopy, especially if conducted while a sensor is being worked under standard operational conditions.

In this presentation, we review the state-of-the-art about metal-oxides as functional materials, show their better application opportunities, and highlight most recent trends in research.

Advanced Imaging of Metamagnetic Micro- and Nano-Structures: From Fundamentals to Biomedicine

Vojtěch Uhlíř[a,b]

[a] *CEITEC BUT, Brno University of Technology, Purkyňova 123, Brno, 612 00, Czechia*
[b] *Institute of Physical Engineering, Brno University of Technology, Technická 2, Brno, 616 69, Czechia*
E-mail: vojtech.uhlir@ceitec.vutbr.cz

Keywords: Phase Transitions, Metamagnetism, Magnetic Imaging, Nanomaterials, MRI

Metamagnetic materials such as FeRh exhibit intriguing phase transitions with new functionalities at meso- and nanoscales. In this talk, I will present recent advances in the study of FeRh micro- and nanostructures, where local control of the antiferromagnetic (AF)–ferromagnetic (FM) transition is achieved via strain, magnetic fields, and ultrafast laser pulses. Our work reveals the asymmetric phase transition dynamics in confined FeRh structures [1,2], with spatially resolved studies extending from continuous films to patterned nanoislands [3,4]. Advanced electron microscopy techniques, including Lorentz Transmission Electron Microscopy and Differential Phase Contrast, allow unprecedented visualization of phase coexistence and magnetic domain structures at the nanoscale.

Moving towards biomedical applications, we demonstrate the feasibility of using FeRh microstructures as switchable MRI contrast agents [5]. Fabricated arrays of micron-sized FeRh particles exhibit reversible field-controlled AF-FM transitions, enabling dynamic control of MRI contrast at biologically relevant scales and temperatures. These results pave the way for developing low-energy, field-responsive probes for biomedical imaging.

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E-field Assisted Assembly of Metal-Organic Framework Particles with Surface Polymerizable Ligands: Towards Modular Colloidal Chains

Alejandra Durán Balsa[a], Youven Benseghir[a], Flora Schöfbeck[a], Jiamin Chin[a*],

[a] *Institute of Functional Materials and Catalysis, Faculty of Chemistry, University of Vienna, Währinger Str. 42, Vienna, Austria*
E-mail: alejandra.duran.balsa@univie.ac.at

Keyword: MOFs, Colloidal Assembly, E-field, 1D Chains, Magnetic Particles

Colloidal assembly has become an indispensable tool to engineer new materials with emergent properties, with metal-organic frameworks standing out as promising building blocks due to their tunability at the molecular level.[1,2] 1D assemblies, or colloidal chains, are especially interesting due to their anisotropy, continuous mass and charge transport pathways, and increased stability, making them uniquely suited for applications requiring directional mass transport and higher dispersion stability such as nanocarriers for catalysis or as magnetic colloids.[3-5] Current MOF chain assembly techniques require very specific particle design, limiting the approach to certain materials, or they do not result in stable chains upon changing the assembly conditions.[6,7] In this work, we combine E-field assisted assembly with UV polymerizable ligands on MOF particles to form stable colloidal chains whilst retaining MOF porosity and allowing for recovery of the chains. We use methacrylate-functionalized ZIF-8 particles as a model, noting the chain formation of particles of varying sizes, and subsequently apply the method to magnetized ZIF-8 particles, creating magnetic chains that respond to a magnetic field. Furthermore, we showcase the robustness of the method by preparing mixed chains containing both ZIF-8 particles and a magnetized ZIF-8 particle which extends its magnetic rotation to the whole chain, creating a responsive micro -rotor. Lastly, we chain UiO-66 particles, indicating our method is translatable to different MOF classes. The facile methacrylate functionalization can be employed with amine bearing MOFs, and it works for MOFs capable of hosting guests, such as ZIF-8, making this widely applicable to create diverse 1D assemblies of single or multiple MOF components with different functionalities, thus opening the door to a myriad of tailored applications.

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Synthesis and characterization of molybdenum disulfide nanoflowers, their use in electrochemical sensor fabrication for the determination of linagliptin and the effect of platinum nanoparticle decoration on analytical response

Ali Kemal Ateş[a]

[a] *Dicle University, Faculty of Pharmacy, Department of Analytical Chemistry, 21280, Diyarbakır, Türkiye*
E-mail: alikemal.ates@dicle.edu.tr

Keyword: Molybdenum disulfide, nanoflower, platinum nanoparticles,

Drug analyses are an important field of study in analytical chemistry. Among the analytical methods used for this purpose, electroanalytical methods stand out with their features such as cost-effectiveness, short analysis time and easy applicability. While developing electroanalytical methods, surface modified sensors with various nanomaterials are used rather than commercially available electrochemical sensors. In this way, more selective and sensitive sensors with improved electrical properties can be developed for the target analyte. Molybdenum disulphide (MoS_2), a transition metal dichalcogenide, consists of a molybdenum layer between two sulphur layers held together by weak van der Waals bonds. Its 2-dimensional layered structure is a widely preferred nanomaterial in electrochemical sensor production due to its high electron mobility. There are a considerable number of electrochemical sensors based on MoS_2 nanosheets decorated with various materials such as metal nanoparticles, conducting polymers and amino acids in the literature.

In this study, it is aimed to synthesize MoS_2 in nanoflower structure (MoS_2NFs), to decorate platinum nanoparticles (PtNPs) on these synthesized nanoflower structures, to produce electrochemical sensors with these nanostructures and to investigate the electrochemical behaviour of linagliptin (LNG), an anti-diabetic drug, on the surface of these sensors. Sensor fabrication was carried out by dropping the dispersion of MoS_2NFs and PtNPs decorated MoS_2NFs (PtNPs@MoS_2NFs) in water onto the screen-printed carbon electrode (SPCE) surface and drying. These sensors were investigated by electrochemical impedance spectroscopy, and it was observed that the charge transfer resistance of MoS_2NFs modified SPCE (MoS_2NFs/SPCE) and PtNPs@MoS_2NFs decorated SPCE (PtNPs@MoS_2NFs/SPCE) decreased compared to bare SPCE which makes them more ideal sensors. In addition, the electroactive surface areas of developed sensors were calculated. The electroactive surface area of PtNPs@MoS_2NFs/SPCE was found ~80% higher than of MoS_2NFs/SPCE. Afterwards, electrochemical behaviour of LNG was investigated on the different sensors by voltammetry. A well-defined oxidation peak was observed around ~0.8 V for all sensors. Moreover, the anodic peak currents obtained on the MoS_2NFs/SPCE and PtNPs@MoS_2NFs/SPCE surfaces were 1.70 and 1.22-fold higher than of obtained on the bare SPCE surface, respectively. In the next part of the study, an electroanalytical method for the determination of LNG using the developed sensors will be developed, validated and applied for the determination of LNG from real samples. In this way, a nano sensor that can be used in quality control studies in drug production facilities will be introduced to the literature.

Acknowledgements: The author's participation in this event was financially supported by Dicle University Scientific Research Projects Coordination Unit.

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Cycloaddition and Cycloisomerization: Unlocking New Pathways to Complex Polycyclic Aromatic Compounds

Angelika Mieszczanin[a], Patrycja Filipek[b], Alina Brzęczek-Szafran[a], Anna Chrobok[a],
Stanisław Krompiec[b]

[a] *Department of Chemical Organic Technology and Petrochemistry, Faculty of Chemistry, Silesian University of Technology, Krzywoustego 4 street, 44-100 Gliwice, Poland*
[b]*Institute of Chemistry, Faculty of Science and Technology, University of Silesia in Katowice, Szkolna 9 street, 40-006 Katowice, Poland*
E-mail: angelika.mieszczanin@polsl.pl

Keywords: cycloaddition, polyaromatic compounds, nanographenes, structure–property relationships

Cycloaddition and cycloisomerization reactions are undoubtedly powerful tools in the synthesis of polycyclic aromatic hydrocarbons, particularly of precisely designed π-extended nanomaterials characterised by strictly defined architecture and tunable properties. These transformations are central in a modern bottom-up and APEX (annulative π-extension) strategies used in the development of advanced nanographenes [1].

In this work, we report the synthesis of novel 7,14-di(mesityl)bisanthene derivatives via selective cycloaddition/cycloisomerisation of selected dienophiles (acetylenes and butadiynes) into one or both bisanthene bay regions. The applied methodology enables not only to precisely expand the π-system, but also rationaly design molecular properties through various dienofile structures and synthetic ways modifications.

The obtained compounds were chromatografically isolated and fully characterized by NMR and HRMS spectroscopy. Preliminary evaluation of their physicochemical properties was also performed. The developed approach provides a versatile platform for constructing complex nanomaterials with great potential for applications in organic electronics and related fields [2].

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Combining of chemical treatment and UV-Vis irradiation process for preparation of conductive materials based nickel@silver core@shell nanoparticles

Anna Pajor-Świerzy, Katarzyna Kozak, Dorota Duraczyńska, Krzysztof Szczepanowicz

Jerzy Haber Institute of Catalysis and Surface Chemistry Polish Academy of Sciences, Niezapominajek 8, 30-239 Kraków, Poland,
E-mail: ncpajor@cyf-kr.edu.pl

Keyword: Core@Shell Nanoparticles, Oxalic Acid, UV-Vis spectrophotometery, Conductivity, Metallic coatings

Core@shell bimetallic nanoparticles (NPs) as the main ink component for application in printed electronics have attracted much attention [1, 2]. The crucial importance of this process is obtaining patterns containing such NPs with conductivity close to that of their bulk counterpart using low-cost technology. The ink properties (e.g. nanoparticle shape, size, stability against aggregation, solid content, and rheology), substrate characteristics (surface energy, wetting properties, smoothness/roughness) as well as the printing method affect the functionality and properties of the printed or deposited nanoink circuits or coatings. In this context, the process of the forming of printed conductive materials involves three stages: (1) NP-based ink preparation, (2) its deposition or printing by proper techniques, and (3) post-printing treatment of obtained coatings or circuits, e.g. drying and sintering.

In our work, we applied a modified approach to fabricating coatings with conductive properties formed from nickel@silver core@shell NPs at low-sintering temperatures. This method was based on using a combination of two different sintering processes. The deposited films were treated with oxalic acid and then the UV-Vis irradiation process was used. The application of such sintering methods allowed for obtaining metallic coatings with good conductivity. It was also noticed that its value depends on the thickness of the silver shell-coated nickel nanoparticles. The highest value of conductivity (about 50% of that for a bulk nickel) was achieved for metallic coatings composed of nanoparticles with the thickest Ag shell (55 nm) after 90-240 minutes of the UV-Vis irradiation process.

The obtained results are promising for the application of ink based on Ni@Ag NPs for the fabrication of conductive circuits on low-cost heat-sensitive substrates such as polymers or paper and can pave the way for the production of various types of flexible printed electronic devices. Although low-temperature sintering process for the fabrication of conductive materials offers many advantages, including energy efficiency and the ability to create novel electronic, flexible materials. We are also aware, that the transfer of this process from laboratory scale to commercial production can be problematic, and usually the engineering as well as scientific challenges have to be overcome.

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Innovative water-in-oil-in-water emulsion for the preparation of polydispersed poly (methyl methacrylate) and polystyrene microspheres with fluorescent labelling

Emma Cénac-Morthé [a], Julien Cambedouzou [a], David Cornu [a], Mikhael Bechelany [a], Christophe Charmette [a] , Yasmine Colombani [b] , Arnaud Bourdin [b], Olivier Cazorla [b],

[a] *Institut Européen des Membranes, IEM, UMR 5635, Univ Montpellier, ENSCM, Centre national de la recherche scientifique (CNRS), Place Eugène Bataillon, 34095 Montpellier*
[b]*Laboratoire d'étude Physiologie et médecine expérimentale du cœur et des muscles, PhyMedExp, Institut National de la Santé et de la Recherche Médicale (INSERM), CHU Arnaud Villeneuve, 371 Avenue du doyen Gaston Giraud, 34295 Montpellier*

Keyword: Double emulsion, fluorescent labelling, PS, nanospheres, air pollution.

Atmospheric micro and nanoplastics (MNPs) have become an emerging source of concern suspected to cause the development of pulmonary and cardiovascular diseases such as the Chronical Obstructive Pulmonary Disease (COPD), mostly the particle matter below 2.5 µm of diameter, called PM2.5. Due to the difficulty to analyze this airborne polymeric pollution in suspension as well as inside the lung tissues there is a need to design traceable nanomaterials with the airborne pollutant properties. Different approaches exist but mostly involve surface functionalization which requires additional steps and the use of organic solvents This is why double emulsion –often use for drug carrier synthesis- presents advantages regarding the labelling of microspheres.

Water-in-oil-in-water double emulsion (W/O/W double emulsion) has emerged as a promising approach, combining simplicity, versatility, and sustainability to conceive polydispersed microspheres. This process generates hollow microspheres that enables the use of fluorescent labelling dyes in-situ without additional grafting steps, at room temperature. It is also an easy way to provide a high amount of different polymers such as Polystyrene (PS) and Poly(methyl methacrylate) (PMMA) nano and microspheres from waste materials.

In this study, we investigate the influence of Polyvinyl alcohol (PVA) ratio over the size of the microspheres, synthesized via the W/O/W double emulsion technique as well as the incorporation of fluorescent dyes inside PS and PMMA microspheres. The obtained microspheres are in the range of PM2.5 and exhibit fluorescence. The spheres are polydispersed and their sizes can be tailored by changing the concentration of PVA, reaching submicronic diameters. Their morphology and chemical purity are assessed by characterization methods including Scanning Electron Microscopy (SEM), Dynamic Light scattering (DLS) and Raman and IR spectroscopy. Additionally, the synthesis was performed using PS ships from packaging waste. This experience demonstrated no difference with the commercial PS, showing the transferability of the process.

These results highlight the potential of W/O/W double emulsion for labelled nanosphere and microsphere production, validating their suitability for in vivo tracking applications. This work lays the foundation for advancing investigations linking airborne pollution and respiratory toxicological assays, setting the stage for improved comprehension of MNPs health risks. These microspheres can be useful for in vitro and in vivo assays that better imitate the airborne expositions.

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Green synthesis of zinc tetrahydroxide bis nitrate nanoparticle additives for jet fuel and effects on NOx production

Glemarie Hermosa [a], Protima Rauwel [b] and Erwan Rauwel [a]

[a]*Institute of Veterinary Medicine & Animal Sciences, Estonian University of Life Sciences, Kreutzwaldi 62, 51006 Tartu, Estonia*
[b]*Estonian Aviation Academy Lennu 40, Reola, Kambja, Tartu 61707, Estonia*

E-mail : glemarie.hermosa@emu.ee

Keyword: Nanoadditives, Zinc based particles, Green synthesis, Gas turbine engine

The demand for energy and environmental concerns have increased the need for sustainable and efficient fuel alternatives, especially in the aviation industry [1]. In this context, nanoadditives offer a credible approach to enhance the performance of conventional jet fuels. Among various nanomaterials, zinc-based compounds have the functionality of combustion catalyst. These zinc based nanomaterials possesses high oxygen content and thermal reactivity [2,3], making it a promising nanoadditive. This study introduces a novel, solvent-free synthesis of zinc tetrahydroxide bis nitrate ($Zn_3(OH)_4(NO_3)_2$) nanoparticles as fuel nanoadditives derived from used rapeseed cooking oil, a readily available and low-cost waste resource. To our knowledge, this is the first report of synthesizing this zinc compound directly from used vegetable oil under mild thermal and mechanical conditions. The synthesis involved the direct addition of zinc nitrate hexahydrate to filtered used rapeseed oil, followed by thermal treatment at 110°C, 130°C, and 150°C for one hour. Continuous homogenization was maintained ensuring uniform mixing and consistent heat distribution. X-ray diffraction (XRD) confirmed the formation of crystalline $Zn_3(OH)_4(NO_3)_2$, and structural refinement via the Rietveld method confirmed the monoclinic structure with good crystallinity. FTIR spectra showed characteristic Zn–O stretching bands, strong hydroxyl absorption, and C–N stretching bands (~1200–1350 cm^{-1}). UV–vis analysis revealed an absorption peak at ~280–290 nm and optical band gap of approximately 3.2–3.3 eV. Stability tests of nanoparticle dispersions in jet fuel under UV exposure showed stable optical transmittance for up to two hours highlighting the formation of colloid. Preliminary combustion tests of jet fuel blended with $Zn_3(OH)_4(NO_3)_2$ nanoparticles showed reduced greenhouse gas emissions, indicating improved combustion efficiency, but also an decrease in NOx formation. Moreover, $Zn_3(OH)_4(NO_3)_2$ nanoparticles represent a newly developed class of multifunctional additives that can potentially meet the goal of cleaner combustion. The combination of waste-derived nanomaterials into aviation fuel not only enhances performance but also contributes to circular economy goals by repurposing used cooking oil.

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Biomass-derived Luminescent Carbon Nanodots for Sustainable Optoelectronic and Biomedical Applications

Junkai Ren[a], Henry Opoku[a], Shi Tang[a], Ludvig Edman[a, b], Jia Wang[a, b]

[a] *Department of Physics, Umeå University, SE-90187 Umeå, Sweden*
[b] *Wallenberg Initiative Materials Science for Sustainability, Umeå University, SE-90187 Umeå, Sweden*

E-mail: jia.wang@umu.se

Keyword: Carbon nanodots, Bio-derived, Luminescent materials

Luminescent materials utilized in current optoelectronic and biomedicine applications, such as rare-metal phosphors, inorganic quantum dots and organic semiconductors, often necessitate critical raw materials, heavy metals, and petroleum-based chemicals for synthesis and purification. Their synthesis, purification, and recycling pose significant sustainability challenges linked to resource depletion and electronic waste.

Carbon nanodots (CNDs) are emerging as a novel luminescent nanomaterial with tunable emission, a high photoluminescence quantum yield, and robust photo-/chemical stability. Importantly, CNDs can be synthesized from abundant and renewable biomass and bio-derived precursors, making them more sustainable alternatives than conventional luminescent materials.

We present the synthesis and characterization of highly luminescent CNDs from both bio-derived small molecules and plant-based biomass, with a strong emphasis on sustainable synthesis routes.[1-8] The structure characterizations and photophysical studies revealed the construction process and luminescence mechanisms of these CNDs. We have also explored their application as emitters in organic light-emitting devices, gain media in random lasers, and antioxidants in biomedical applications.[9, 10] Our results highlight the feasibility of developing bio-based CNDs as sustainable luminescent materials for eco-friendly applications across multiple fields.

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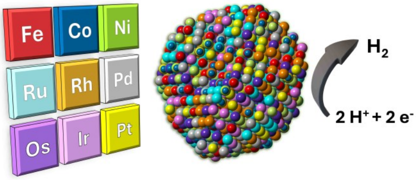
All Iron-Group and Platinum-Group Elements Metal High-Entropy Alloy Nanoparticles

Julien Mahin[a], Kohei Kusada[ab], Megumi Mukoyoshi[c], Tomokazu Yamamoto[d], Takaaki Toriyama[d], Yasukazu Murakami[d], Osami Sakata[e], Shogo Kawaguchi[e], Hirotaka Ashitani[e], Yoshiki Kubota[f] and Hiroshi Kitagawa[c]

[a] *Institute for Advanced Study, Kyushu University, 6-1, Kasugakoen, Kasuga City, Fukuoka, 816-8580, Japan*
[b] *Interdisciplinary Graduate School of Engineering Science, Kyushu University, 6-1, Kasugakoen, Kasuga City, Fukuoka 816-8580, Japan*
[c] *Graduate School of Science, Kyoto University, Kitashirakawa-Oiwakecho, Sakyo-ku, Kyoto 606-8502, Japan*
[d] *The Ultramicroscopy Research Center, Kyushu University, 744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan*
[e] *Center for Synchrotron Radiation Research, Japan Synchrotron Radiation Research Institute (JASRI) SPring-8, 1-1-1 Kouto, Sayo-cho, Sayo-gun, Hyogo 679-5198, Japan*
[f] *Graduate School of Science, Osaka Metropolitan University, 1-1 Gakuen-cho, Naka-ku, Sakai, Osaka 599-8531, Japan*
E-mail: mahin.julien.luca.a.872@m.kyushu-u.ac.jp

Keyword: High-Entropy Alloy; Iron-Group Metals; Platinum-Group Metals; Hydrogen Evolution Reaction; Electrocatalyst

High-entropy alloys, composed of 5 or more principal elements, are highly promising materials as catalysts for important energy transformation reactions[1]. So far, the research focus has been on noble metals such as the platinum-group metals because of their exceptional catalytic properties and because they are relatively easy to mix owing to their similar properties[2,3]. However, it is of great interest to study the alloying of more diverse elements such as 3d metals into platinum-group metal high-entropy alloys and study the effect of the addition of elements with very different sizes and d-band center energy on the catalytic activity. The different properties of the 3d metals compared to the 4d and 5d metals make such single-phase alloys very challenging to synthesize, particularly at the nanoscale, normally requiring extreme reaction conditions. We synthesized for the first time alloy nanoparticles containing all the iron-group metals (Fe, Co and Ni) and all the platinum-group metals (Ru, Rh, Pd, Os, Ir and Pt) using a simple low temperature wet chemical method[4]. We show that remarkably, alloying the iron-group base metals with the platinum-group metals results in a 30% increase in the catalytic activity for the hydrogen evolution reaction under acidic conditions compared to the equivalent alloy containing only platinum-group metals conditions. This activity is three times that of a commercial Pt/C catalyst, enabling reduction of the precious metal content of heterogeneous catalysts while simultaneously increasing their performance.



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Photoelectrochemical characteristics of nanostructured electrodes based on SnO_2

Magdalena Gurgul[a], Leszek Zaraska[a]

[a] *Jagiellonian University, Faculty of Chemistry, Gronostajowa 2, 20 20-287 Krakow, Poland*
E-mail: gurgulm@chemiaa.uj.edu.pl

Keyword: SnO_2 inverse opals, photonic bandgap, photoelectrochemical properties

Due to increasing energy demand and gradually progressing climate threats, photoelectrochemical water splitting offers a promising approach to converting solar energy into clean hydrogen fuel [1]. In this regard, periodically ordered macroporous structures, 3D inverse opal (IO) structures (which are inverse replicas of 3D colloidal crystals) are extraordinary due to their large surface area and exceptional optical properties. The origin of the latter lies in periodically ordered pore distribution and, thus, periodic dielectric contrast [2]. As a result of this, IO-based materials contain some of the optical properties of photonic crystals, i.e. photonic bandgap (PBG) and slow photon effect [3].

Despite the wide E_g, tin(IV) oxide seems to be especially appealing due to its high refractive index, stability in aqueous solutions and the potential value of the valence band, which enhances charge separation and prevents hole recombination, especially regarding more complex, heterojunction-based photoelectrodes [1].

Therefore, this study presents a comprehensive investigation into the influence of synthesis conditions on the structural and morphological characteristics of SnO_2 inverse opals (SnO_2-IOs). Subsequently, the optical, electrochemical, and photoelectrochemical properties of the materials were thoroughly examined and systematically correlated.

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Tuning Surface Chemistry of Activated Carbons to Enhance Chlorobenzene Removal from HCl Effluents

Tânia Grainha, Juliana P. S. Sousa
INL-Iberian Nanotechnology Laboratory, Braga, Portugal
E-mail: tania.grainhal@inl.int

Keywords: Activated carbon, surface functionalization, chlorobenzene removal, fixed-bed adsorption, HCl effluents, lithium-ion battery recycling

Inorganic acids are commonly used in the leaching process of end-of-life lithium-ion batteries (LIBs) due to their low cost and high leaching efficiency. Among these, sulfuric acid is the most frequently used. However, in the pursuit of more environmentally friendly approaches, hydrochloric acid (HCl) has emerged as a promising alternative due to its lower environmental impact and potential for recovery and reuse. Interestingly, HCl is also a by-product of polyurethane production, although it is typically contaminated with chlorobenzene, which makes it unsuitable for direct use in battery recycling. In line with circular economy principles, this project proposes repurposing this waste HCl stream for use in LIB recycling, provided the chlorobenzene—present at approximately 30 ppm—can be effectively removed.

To address this, adsorption was selected as the purification method due to its simplicity, low cost, and ease of scaling up. This project focuses on developing an efficient adsorption process to remove chlorobenzene from the HCl stream, enabling its reuse in the hydrometallurgical treatment of spent LIBs and contributing to both environmental sustainability and resource efficiency.

Activated carbon was selected due to its high surface area, chemical resistance and adaptability to functionalization. The materials were modified with nitrogen-containing precursors (dopamine (DA), melamine (M), polyethylenimine (PEI) and urea (U)) as well as subjected to thermal treatment (TT), with the goal of enhancing adsorption performance through surface chemistry tuning.

The adsorbents were characterized using N_2 adsorption-desorption isotherms at -196 ºC, elemental analysis, thermogravimetric analysis (TGA), and point of zero charge (pH_{pzc}) measurements.

Fixed-bed column studies were carried out using HCl solutions containing 30 ppm of chlorobenzene, under controlled flow and bed height conditions. Adsorption results showed distinct performances depending on the carbon type and treatment. The urea-functionalized activated carbon from Sigma exhibited the best performance, achieving 90% removal efficiency (Figure 1-A) and a maximum adsorption capacity of 0.6 mg/g (Figure 1-B). This study contributes to the development of effective strategies for chlorobenzene removal.

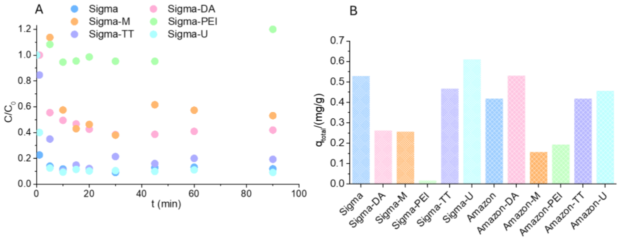

Figure 1. A- Column adsorption study of 30 ppm chlorobenzene onto activated carbon at a flow rate of 4.1 mL/min. B- Total amount of chlorobenzene adsorbed (q_{total}) with the different materials.

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Unveiling Growth Mechanisms of BN flakes coated CNT Heterostructure

Tongshan Liu[1], Xingyi Yan[2], David G. Hopkinson[3], Christopher S. Allen[13], Barbara M. Maciejewska[1]*, Mark Wilson[2]*, and Nicole Grobert[1]*

[1]*Department of Materials, University of Oxford, Parks Road, Oxford OX1 3PH, U.K.*
[2]*Department of Chemistry, Physical & Theoretical Chemistry Lab, University of Oxford, Mansfield Rd, Oxford OX1 3QZ, U.K.*
[3]*Electron Physical Science Imaging Centre, Diamond Light Source Ltd, Didcot OX11 0DE, Oxfordshire, UK*

As the demand for high-performance materials with excellent thermal conductivity grows, carbon nanotubes (CNTs) continue to show remarkable promise. In this work, we present an innovative heterostructure composed of CNTs coated with hexagonal boron nitride (h-BN) layers through chemical vapor deposition (CVD). This structure includes an inner CNT core encased by coaxial boron nitride nanotubes (BNNTs) and topped with h-BN nanoflakes, forming a multi-layered architecture that maximizes surface area and establishes robust channels for phonon transport.

Using advanced characterization techniques, scanning transmission electron microscopy (STEM), electron energy loss spectroscopy (EELS), transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS), and X-ray diffraction (XRD), along with computational modelling, we elucidate the atomic-level structure and growth mechanism of this CNT/BN hybrid. While earlier studies proposed mechanisms for flake growth on nanotube surfaces including graphene or MnO_2 sheet-coated CNTs, direct evidence is needed to substantiate the claims. [1–6] This research provides the first confirmation of the hierarchical growth mechanism of h-BN on CNTs. Our findings reveal that h-BN initially forms as coaxial BN nanotubes (BNNTs) encapsulating the CNTs, with BN flakes subsequently developing from structural defects in the outermost BNNT layer. This study not only provides the first insight into the nanoflake growth on CNT surfaces but also confirms the stability of this van der Waals heterostructure.

The enhanced heat transfer properties and structural integrity of this CNT/BN material make it a promising candidate for thermal dissipation technologies, particularly in high-performance electronics and energy storage systems. This research not only deepens our understanding of tree-leaf heterostructures but also introduces new approaches for synthesizing CNT@BN materials. The findings broaden the potential for CNT applications in fields that demand advanced thermal management.

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Advancing SERS with Plasma-Tailored Nanoparticles

Vasyl Shvalya[a], Jaka Olenik[a]

[a] *Department of Gaseous Electronics, Jožef Stefan Institute, Jamova cesta 39, SI-1000, Ljubljana, Slovenia*

E-mail: vasyl.shvalya@ijs.si

Keywords: Plasma, SERS, Nanoparticles, DNA, Explosives

Gold nnanoparticles are indispensable in a wide range of cutting-edge technologies, even though each application requires precisely defined dimensions and shapes. In heterogeneous catalysis and photothermal treatment systems, sub-10 nm particles with strong plasmonic absorption are favoured, while in-vivo imaging and plasmon-enhanced spectroscopy benefit from a higher order multi-twinned morphology that enables intense light scattering and finely tuned resonances. These different requirements have led to two overarching fabrication strategies: surfactant-mediated and surfactant-free syntheses, each with different advantages and drawbacks. Surfactant-assisted synthesis routes offer reasonable control over shape, colloidal stability and optical bandwidth; however, their capping ligands obstruct the active surface sites, which compromises catalytic and sensing performance. In fact, the surface-enhanced Raman scattering (SERS) intensity of ligand-coated AuNPs can be an order of magnitude lower than that of ligand-free analogues. The toxicity and biocompatibility issues associated with certain surfactants emphasise the need for more environmentally friendly manufacturing methods.

Plasma–liquid chemistry has recently proven to be a fast, reagent-free and environmentally friendly way to produce AuNPs without external reducing agents or stabilisers. Beyond pure synthesis, the high-energy species in the non-thermal atmospheric plasma induce a high density of twin boundaries within the Au lattice, strongly enhancing local electromagnetic "hot spots" This twinned architecture delivers maximum SERS efficiency per unit particle volume, outperforming conventional quasi-spherical counterparts. We present here our methods for tuning particle size, morphology, twin density and ultimate SERS performance in surfactant-free AuNPs prepared with such plasmas, and we demonstrate SERS applications for aliphatic and aromatic explosives detection and GC ratio monitoring in bacterial DNA [1, 2].

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Inorganic oxide composite nanomaterials with pronounced bioactivity for biomedical application

Yuliia Shlapa[a], Katarina Siposova[b], Veronika Sarnatskaya[c], Anatolii Belous[a]

[a] Department of Solid-State Chemistry, V. I. Vernadsky Institute of General and Inorganic Chemistry of the NAS of Ukraine, 32/34 Palladina ave., Kyiv, 03142, Ukraine
[b] Department of Biophysics, Institute of Experimental Physics, Watsonova 47, Kosice 040 01, Slovakia
[c] Department of Ecology and Sorption Toxicology, R. E. Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology of the NAS of Ukraine, 45, Vasylkivska str., Kyiv, 03022, Ukraine
E-mail: yuliashlapa@ukr.net

Keyword: Synthesis, Nanocomposites, Cerium Dioxide, Bioactivity

At present, inorganic nanomaterials attract significant attention for their potential use in biomedicine. One of the possible directions is the development of nanomaterials capable of suppressing the appearance of oxidative stress, which can be a reason or consequence of various diseases, from cancer therapy to neurodegenerative diseases or irradiation. For practical use in medicine, nanomaterials should possess multifunctionality because it is often necessary to apply a complex procedure for successful therapy. It can be achieved by developing composite nanomaterials consisting of two or more components, ensuring the possibility of consolidating several functionalities in one nanocomposite, improving surface characteristics, chemical and colloidal stability, the occurrence of synergistic interactions, new or enhanced functionalities, etc. [1].

This research aimed to synthesize two types of biocompatible nanocomposites based on CeO_2 NPs known by their high bioactivity and biocompatibility and assess the interplay between their physicochemical parameters and bio-functionality.

A set of C@CeO_2 composites was synthesized based on activated carbon and CeO_2 NPs by the homogenization of pre-fabricated individual components in the planetary mill. The collected experimental data documented the formation of composites, in which CeO_2 NPs are anchored on the surface of carbon particles that can be connected to two possible mechanisms: i) adsorption of the part of CeO_2 NPs by carbon particles and ii) occurrence of some interaction between carbon surface and CeO_2 NPs with Ce^{3+}/ Ce^{4+} ion couple at the surface. The results of biological testing of C@CeO_2 composites indicated their synergistically increased bioactivity expressed as pseudo-enzymatic and radioprotective activities. Some interplay was observed between the redox state of the composites' surface and their bioactivity, and a feasible mechanism of the biocatalytic processes was suggested [2].

A set of magnetic Fe_3O_4@CeO_2 nanocomposites was synthesized using two different methods. The results of detailed physicochemical characterization revealed that synthesis conditions significantly affect the morphology of nanocomposites and the balance of Fe^{2+}/Fe^{3+} and Ce^{3+}/Ce^{4+} on their surface. Developed magnetic Fe_3O_4@CeO_2 nanocomposites were tested *in vitro*, and they demonstrated much higher pseudo-enzymatic (antioxidant) potential compared to individual nanoparticles due to the appearance of so-called synergistic effect. In particular, it was found that a synergistic increase in bioactivity was observed for nanocomposites, whose surface is enriched with Fe^{2+} and Ce^{3+}, which actively participate in the biocatalytic processes [3].

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Changing hydrodynamic conditions to obtain AAO layers with complex channel geometry

Aleksandra Świerkular[a,b], Leszek Zaraska[a],

[a] *Faculty of Chemistry, Jagiellonian University, Gronostajowa 2, 30-387 Kraków, Poland*
[b] *Doctoral School of Exact and Natural Sciences, Jagiellonian University, prof. S. Łojasiewicza 11, 30-348 Kraków, Poland*
E-mail: aleksandra.swierkula@doctoral.uj.edu.pl

Keyword: Anodic alumina, Anodization, Nanoporous materials, Synthesis Modification, Joule Heating

Anodic Aluminum Oxide (AAO) is widely used in different fields of science and technology. Proper adjustment of anodization conditions such as voltage[1] or type of electrolyte[2] enables to obtain oxide layers with straight or serrated channels. During the anodization in acidic electrolytes, the Joule heat is also generated, which causes an increase of electrolyte temperature and the dissolution of the aluminum oxide[3]. The electrolyte stirring enables dispersion of excess heat during synthesis, consequently leading to the formation of layers with uniform channels . However, little research has been done to verify how the change in hydrodynamic conditions affects the AAO morphology[4],[5]. Already published works proved that current density values are strongly affected by the stirring of the electrolyte. Therefore, by simply alternating the hydrodynamic conditions during the anodization the formation of channels with modulated diameter can be expected, as a result of different efficiency of Joule heating dissipation from the pore bottom.
The purpose of this work was to investigate the possibility of obtaining the AAO layers with modulated diameter by simple changing the hydrodynamic conditions during the anodization.

AAO layers were obtained during the two-step anodization of aluminum foil with different thicknesses. The process was carried out at room temperature and constant voltage in two types of electrochemical cells (with horizontal and vertical placement of samples). The oxalic acid solutions with different concentrations were used as electrolytes, and anodization was carried out with or without electrolyte stirring. The oxide layers morphology was investigated with a SEM microscope, and the current-time curves were recorded for kinetics investigation. It was confirmed, that, depending on the cell geometry, the non-stirring of the electrolyte caused an increase (in the case of an electrochemical cell with vertical sample placement) or a decrease in the current density (in the case of horizontal sample placement in an electrochemical cell). This resulted in both cases in the formation of oxide layers with different diameters within one channel.

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Morphology Controlled Low-Temperature CVD Synthesis of SnO_2 Nanocones for Photoelectrochemical Applications

Bartłomiej Orczykowski[a, b], Magdalena Gurgul[b], Leszek Zaraska[b]

[a]*Jagiellonian University, Doctoral School of Exact and Natural Sciences,*
Prof. St. Łojasiewicza St 11, PL30348, Cracow, Poland
[b] *Jagiellonian University, Faculty of Chemistry, Department of Physical Chemistry and Electrochemistry, Gronostajowa 2, PL30387, Cracow, Poland*
E-mail: bartlomiej.orczykowski@doctoral.uj.edu.pl

Keyword: Nanocones, Photoelectrochemical water splitting, Chemical vapor deposition

In recent years, nanostructured semiconductive tin(IV) oxide has been an intensively studied material due to its exceptionally favorable physicochemical properties that make it a promising candidate in various fields, such as gas sensors [1] or UV light detectors [2]. Moreover, SnO_2 has been identified as a potential photoactive material that can be used in the process of photoelectrochemical (PEC) water splitting, making it a promising direction for further research and development. Furthermore, it is known that by employing one-dimensional nanostructures (such as nanocones) improved transport path for photogenerated charge carriers transport can be obtained, resulting in enhanced photoactivity when compared to their 2D or 3D nanostructured counterparts.

One of the most promising methods of obtaining SnO_2 nanocones is chemical vapor deposition (CVD), but while effective, the usage of high-vacuum chambers, extremely high temperatures and specialized equipment are factors limiting its application, especially in a large-scale production. Recently, modified CVD method of obtaining the SnO_2 nanostructures has been developed by Wang et. al. [3], simplifying the synthesis route. Although the method has been successfully used to synthesize tin(IV) oxide nanocones, a comprehensive showcase of changes to the nanostructures' morphology and its effects on the photoelectrochemical and optical properties based on parameters of the performed process has not been previously optimized and presented.

Therefore, this study explores the characterization of tin(IV) oxide (SnO_2) one-dimensional (1D) nanostructures, resembling nanocones, synthesized via a modified low-temperature chemical vapor deposition (CVD) method. A clear correlation between SnO_2 nanocone morphology and its photoelectrochemical activity was established and explained. We focused on the relationship between the masses of used tin(II) chloride dihydrate and zinc chloride anhydride during the synthesis and the morphological features of the obtained nanostructures. Morphology of the nanocones was analyzed using SEM microscopy, while the composition and further properties were investigated using SEM, XRD, XPS and Raman spectroscopy techniques, revealing differences in crystallinity and diameter-dependent structural variations. Furthermore, the material's optical properties were analyzed using UV-Vis spectroscopy, while its photoelectrochemical properties were examined under illumination using a solar simulator and monochromatic light sources. All analyzed properties were correlated with morphological features of the analyzed samples.

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Synthesis of Nickel Nanoparticles Encapsulated with Carbon via Reactive Inductively Coupled Thermal Plasma

Chulwoong Han

[a] *Korea Institute of Industrial Technology, Incheon, 21999, Republic of Korea*
E-mail: hcholw@kitech.re.kr

Keyword: Nickel, Inductively Coupled Thermal Plasma, Carbon, Binary system, Nanoparticle

The pursuit of higher energy density and improved performance in multi-layer ceramic capacitors (MLCCs) has long been a challenge. One effective approach has been reducing the thickness of the metallic conductive layer, typically achieved through the use of nanoparticles. However, the size-dependent effects of nanoparticles introduce a paradox in MLCC manufacturing: as the particle size of metallic nickel decreases, its surface area-to-volume ratio increases, which enhances reactivity. This heightened reactivity can lead to problems such as air oxidation and premature sintering, ultimately degrading the electrical performance of the sintered conductive layer.

To address this paradox, ceramic components have been incorporated into nickel nanoparticles, primarily to suppress sintering, albeit at the cost of some electrical properties. In this study, a Ni–C binary nanoparticle system was selected as a promising solution to the MLCC manufacturing paradox. Specifically, Ni/C core–shell nanoparticles were identified as a strong candidate due to their potential to mitigate oxidation and control sintering behavior. The carbon shell can protect the nickel core from air oxidation, while the temperature-dependent solubility of carbon in the Ni–C system enables manipulation of the sintering temperature and the microstructure of the sintered body through dissolution–precipitation reactions.

Ni–C binary nanoparticles were synthesized using inductively coupled thermal plasma (ICTP) from a Ni–C powder feedstock. The synthesized particles were characterized and frequently observed to consist of carbon-encapsulated nickel nanoparticles. However, strictly speaking, the nanoparticles were a mixture of nickel-rich particles and carbonaceous particles. Thick films were fabricated by screen printing, followed by binder burnout and sintering. Compared to pure nickel thick films, those incorporating Ni–C nanoparticles exhibited significantly lower electrical resistance.

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Nanophosphor incorporated metal alloy for anticounterfeit application

Dhanya Sunil[a], Anand P J[b]

[a] *Department of Chemistry, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, Karnataka, India*
[b]*Manipal Technologies Limited, Manipal, Karnataka, India.*
E-mail: dhanyadss3@gmail.com

Keyword: Alloys, Nanophosphor, Anti-counterfeiting

Counterfeiting of metal alloys poses a significant challenge in industries where material integrity is critical, such as aerospace, automotive, construction, and electronics. The infiltration of counterfeit alloys can lead to severe consequences, including product failures, safety hazards, financial losses, and damage to the reputation of legitimate manufacturers. To address this growing concern, various authentication technologies are currently employed to detect and prevent the circulation of counterfeit materials.

This study introduces an innovative solution to counter the escalating threat of counterfeit metal alloys, which carry substantial economic, safety, and legal implications. A novel high-security metal alloy has been developed by integrating an upconversion nanophosphor into a lead-based alloy, offering a built-in, dual-layered anti-counterfeiting system. This system features both visual and auditory authentication mechanisms without compromising the alloy's functional performance. When exposed to a 980 nm light source, the material exhibits a distinctive distance-dependent multi-color emission pattern—emitting a vivid red glow at close range, shifting to orange at an intermediate distance, and reverting to red when viewed from farther away.

In addition to visual identification, the material incorporates an auditory authentication feature. When scanned with an infrared (IR) taggant detector, it emits a beep sound, providing an additional layer of verification. Unlike conventional methods that rely on external security measures, this novel approach embeds anti-counterfeiting features directly within the alloy, enhancing security and resistance to tampering. By combining visual and auditory authentication techniques, this system offers a robust, reliable, and tamper-proof solution for mitigating the risks associated with counterfeit metal alloys.

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MoB and Mo_2B_2 MBenes for Enhanced Photocatalytic Decomposition of Organic Pollutants

Dominika Bury [a*] Michał Jakubczak [a], Abiyyu Kenchi Purbayanto [a], Dorota Moszczyńska [a], Agnieszka Maria Jastrzębska [a]

[a] *Faculty of Mechatronics, Warsaw University of Technology, św. Andrzeja Boboli 8, 02-525 Warsaw, Poland*
E-mail: dominika.bury.doktl@pw.edu.pl

Keyword: 2D nanomaterials, MBenes, photocatalysis, optical properties

Two-dimensional (2D) materials have attracted considerable attention in recent years due to their unique structural and physicochemical properties. Among them, MXenes - 2D transition metal carbides - have shown great potential in various applications, particularly in energy and environmental technologies. However, their chemical instability under certain conditions limits long-term performance, prompting the search for alternative 2D materials [1].

A novel and largely unexplored class of materials, known as MBenes, has emerged as a promising candidate. These transition metal borides, first introduced in 2015 by Ade and Hillebrecht, are derived from layered MAB phases, where "M" represents an early transition metal, "A" is an element from group IIIA or IVA, and "B" is boron [2].

In this work, we report the successful synthesis and characterization of MoB and Mo_2B_2 MBenes, produced by selective etching of MoAlB in an aqueous HCl/H_2O_2 solution. The resulting flakes, ranging from single to few layers, exhibited an orthorhombic lattice structure confirmed via X-ray diffraction (XRD). Optical characterization revealed the presence of molybdenum oxides, contributing to direct and indirect band gaps. The photocatalytic performance of MoB and Mo_2B_2 MBene was evaluated through the degradation of methylene blue and tetracycline as model organic pollutants. To demonstrate real-world relevance, we extended the tests to industrial dyes and pharmaceutical contaminants, including doxycycline. Under ultraviolet and simulated sunlight irradiation, the MBene catalyst achieved up to 90% degradation efficiency [3].

Additionally, the material retained its activity after recovery and reuse, highlighting its potential for sustainable applications. These results position MBenes as a promising photocatalyst for environmental remediation. Further research into its properties and modification strategies may unlock broader applications in water treatment and green chemistry [3].

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Preparation and Optical Characterization of Plasmonic Pd/Au Nanostructures for Hydrogen-Sensitive Using Fiber-Optic Interfaces

Elena Miliutina [a,b], Vasilii Burtsev[a], Václav Švorčík [a], Oleksiy Lyutakov [a]

[a] *Department of Solid State Engineering, University of Chemistry and Technology, Prague, Czech Republic*
[b] *Materials Centre, Faculty of Science, J. E. Purkyně University, Ústí nad Labem, Czech Republic*
E-mail: elena.miliutina@vscht.cz

Keyword: Plasmon, Pd, Optical fiber, Hydrogen sensing

Hydrogen is becoming a popular fuel for various energy systems because it utilization minimizes emissions. However, its widespread use is limited by safety concerns related to its flammability, invisibility, and ability to permeate through traditional materials. This creates a growing demand for sensing platforms that are not only sensitive and selective but also reliable, low-cost, and compatible with real-world operating conditions. In this work, we propose the preparation and characterization of Au/Pd-based [1] plasmonic coatings deposited directly onto the core of optical fibers [2]. These nanostructured surfaces exhibit distinct spectral changes upon hydrogen exposure due to the specific interaction between palladium and hydrogen molecules. To improve stability and the ability to “detect” the plasmon in air, various polymer coatings were tested and investigated [1,3,4]. Among them, polydimethylsiloxane demonstrated the most favorable optical properties, hydrogen permeability, and mechanical flexibility. The sensor’s response was monitored via UV–Vis spectroscopy under different hydrogen concentrations. Clear redshifts in the plasmonic absorption peak were observed starting from 1.2% vol. hydrogen concentration in air, with a linear dependence in the lower concentration range and saturation at higher levels, corresponding to the full occupation of Pd active sites. The sensor also demonstrated fast and reversible response behaviour, with high reproducibility over multiple detection cycles. Tests with interfering gases (NO_2, O_2, and others) produced negligible spectral changes, confirming the high selectivity of the developed sensor. These results demonstrate the potential of nanostructured metal-polymer systems integrated with optical fibers for use in environmental hydrogen monitoring and safety applications.

Acknowledgements
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Synthesis and characterization of photocatalytic TiO_2/Cu composite thin films

Ivana Jelovica Badovinac[a,b], Ivna Kavre Piltaver [a,b], Lucija Črep[a], Daria Jardas Babić[a,b], Iva Šarić Janković[a,b], Karlo Veličan[a], Krešimir Salamon[c], Martina Kocijan[a], Matejka Podlogar[d], Robert Peter[a,b]

[a]*University of Rijeka, Faculty of Physics, Rijeka, Croatia*
[b]*University of Rijeka, Center for Micro- and Nanosciences and Technologies, Rijeka, Croatia*
[c]*Ruder Boskovic Institute, Zagreb, Croatia*
[d]*Jozef Stefan Institute, Ljubljana, Slovenia*
E-mail: ijelov@phy.uniri.hr

Keyword: TiO_2/Cu nanocomposites, thin films, solar photocatalysis, atomic layer deposition, scanning electron microscopy

Various methods for modifying TiO_2-based photocatalysts are being tested in order to improve the photocatalytic properties of TiO_2. In recent years, much attention has been paid to TiO_2-metal composites, in which metal nanoparticles are deposited on the surface of the TiO_2 photocatalyst or incorporated into its matrix. By selecting suitable metal nanoparticles (NP), the photo-generation of charge carriers in TiO_2 can be extended to the visible and near-infrared range, resulting in a material with, for example, better photocatalytic performance in the visible range.

In this work, we prepared thin TiO_2/Cu composite films using the atomic layer deposition method. The Cu-NPs were directly incorporated into the TiO_2 matrix during the growth of the films. The size and amount of Cu NPs in the composite films were adjusted by the number of ALD pulses of the copper precursor ($Cu(OAc)_2$). The structure and morphology of these films were characterised in detail using various analytical techniques: X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS) and UV-Vis spectroscopy. We determined the photocatalytic efficiency of these samples by measuring the degradation of methylene blue in aqueous solution using a lamp that simulates sunlight.

The sample with the lowest Cu content and Cu nanoparticles with a size of a few tens of nanometres shows a 2-fold increase in photocatalytic performance compared to pure TiO_2. The sample with the highest Cu content has the largest Cu particles and shows the worst photocatalytic efficiency, which is due to the high Cu content and lower TiO_2 crystallinity.

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Fabrication and Characterization of Polymer Electrolyte Membranes Incorporating Ion-Conductive Copolymers

Jeongyun Seo[a], Myung-Seok Choi[b]

[a] *Advanced Materials Program, Department of Materials Science and Engineering, Konkuk University, 120 neungdong-ro, Gwangjin-gu, Seoul, South Korea*
[b] *Department of Materials Science and Engineering, Konkuk University, 120 neungdong-ro, Gwangjin-gu, Seoul, South Korea*
E-mail: mchoi@konkuk.ac.kr

Keyword: POEM, single lithium ion conducting polymer electrolyte, ion conductive copolymer, ion conductivity, lithium ion transfer rate, polymer electrolyte

To develop high-performance polymer electrolytes for next-generation lithium-ion batteries, this study focused on the development of ion conductive copolymer electrolytes to improve the ionic conductivity properties of poly(oxyethylene methacrylate) (POEM)-based polymer electrolytes. Existing POEM-based SIPEs had limitations in practical use at room temperature due to its relatively low ionic conductivity. To overcome these limitations, a novel acrylic monomer involving short-chain ethylene oxide was synthesized to further enhance the flexibility of polymer chains and the dissolution of lithium ions, and a POEM copolymer incorporating this monomer was prepared. By preparing copolymers with various compositions and block structures, the effects of polymer chain mobility and lithium-ion transport pathways were systematically analyzed. The structure of the synthesized copolymer was confirmed by NMR and FT-IR spectroscopy. Ionic conductivity was measured using electrochemical impedance spectroscopy (EIS). In particular, the ionic conductivity properties according to temperature changes were analyzed in depth. In addition, in order to reveal the mechanism by which lithium ions move in ion conductive copolymers, the lithium ion conductivity was measured and thermal properties were evaluated by differential scanning calorimetry (DSC) to investigate the correlation with the ion conductivity. Experimental results show that POEM-based copolymer electrolytes containing specific multi-chain ethylene oxide blocks exhibit a 10-fold improvement in ionic conductivity compared to conventional single POEM homopolymers at room temperature. This is interpreted as the result that the copolymer structure provides the optimal environment for the efficient dissociation and movement of lithium ions while lowering the ion transport barrier by increasing the flexibility of the polymer matrix. The POEM-based ion conductive copolymer electrolyte developed in this study is expected to be used as a core material technology for high stability and high-performance lithium ion batteries.

Effect of ethylene oxide-based ion-conducting plasticizers on the properties of lithium-ion conducting electrolyte membranes

Kang-San Lee [a], Myung-Seok Choi [b, *]

[a] *Advanced Materials Program, Department of Materials Science and Engineering, Konkuk University,120 neungdong-ro, Gwangjin-gu, Seoul, South Korea.*
[b] *Department of Materials Science and Engineering, Konkuk University, 120 neungdong-ro, Gwangjin-gu, Seoul, South Korea*
E-mail: mchoi@konkuk.ac.kr (Myung-Seok Choi)

Keyword: Ion-conducting plasticizer, Polymer electrolyte, Ionic conductivity, Electrochemical stability, Composite electrolyte, Lithium-ion battery

This study focuses on the introduction of ion-conducting plasticizers as an effective strategy to improve the ionic conductivity of polymer electrolytes. Conventional polymer electrolytes have been limited in practical applications due to low ionic conductivity and narrow electrochemical stability windows. To overcome these limitations, a novel ethylene oxide-based plasticizer was synthesized and blended with a polyethylene oxide (PEO, MW 200,000 g/mol) matrix to promote lithium-ion transport and modulate the physical properties of the electrolyte.

A composite polymer electrolyte membrane was prepared using this ion-conducting plasticizer, and its ionic conductivity, electrochemical stability, thermal behavior, and mechanical strength were systematically evaluated. Significant attention was given to the effects of plasticizer concentration, ion transport characteristics, and polymer–plasticizer interactions on the overall electrolyte performance. The ion conduction mechanism was elucidated via electrochemical impedance spectroscopy (EIS), thermal stability was confirmed by differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). Additionally, tensile testing was conducted to evaluate the mechanical robustness of the composites.

The results showed that the incorporation of the ion-conducting plasticizer significantly enhanced the ionic conductivity of the polymer electrolyte, which greatly contributed to the performance improvement at the room temperature. The electrolyte fabricated under the optimized conditions exhibited an ionic conductivity that was approximately 9 times higher than that of the pure PEO electrolyte while maintaining electrochemical stability. In addition, the ion-conducting plasticizer improved the processability of the electrolyte and reduced the interfacial resistance by increasing the flexibility of the polymer chains. These results of this study are expected to provide valuable insights for the development of new polymer electrolytes for high-performance lithium-ion batteries, solid electrolytes, and other various electrochemical devices.

Engineering Composite Fe_3O_4-MOF for Sensing and Removal of Diclofenac

Karolina Kukrálová [a], Elena Miliutina [a,b], Marie Tomanová [a], Václav Švorčík [a], Oleksiy Lyutakov [a]

[a] *Department of Solid State Engineering, University of Chemistry and Technology, Prague, Czech Republic*
[b] *Materials Centre, Faculty of Science, J. E. Purkyně University, Ústí nad Labem, Czech Republic*

Keyword: Diclofenac; MOF-801; magnetic; adsorption; electrochemical detection

Diclofenac (DCF), a non-steroidal anti-inflammatory drug, is a growing environmental concern due to its widespread detection in aquatic systems, often persisting through conventional wastewater treatment processes [1]. Its presence, even at nanogram-per-liter concentrations, is a significant threat to aquatic ecosystems [2]. Even at low concentrations, DCF poses significant risks to various organisms, including oxidative stress, tissue damage in vital organs, and an endocrine disruption leading to altered behaviour in fish and other aquatic wildlife [3]. The development of advanced materials capable of both capturing and detecting DCF is therefore essential for environmental protection and water quality monitoring.

In this study, we report the synthesis and characterization of hybrid material based on Fe_3O_4 magnetic particles encapsulated within MOF-801 (metal-organic framework). This composite material benefits from the high surface area and specific pore structure of MOF-801 for enhanced adsorption of DCF, while the magnetic core facilitates easy separation from water [4]. The synthesized Fe_3O_4-MOF-801 composite underwent comprehensive characterization using XRD, SEM-EDX, FTIR and BET analysis to confirm its structural, morphological, and textural properties. The Fe_3O_4-MOF-801 composite demonstrated efficient DCF adsorption from aqueous solutions and enabled its detection via simple incubation followed by FTIR analysis, with sensitivity down to µmol. Moreover, differential pulse voltammetry (DPV) enabled electrochemical detection of DCF using a composite as a working electrode. It turned out to be more sensitive and quantitative approach compared to FTIR. Nonetheless, FTIR remains a valuable complementary method for confirming analyte uptake. This research offers a promising, separable, and effective composite material for addressing the critical issue of pharmaceutical contamination in water.

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Impact of Degradation Factors on the Properties of Conductive Polymers

Karolina Mertin[a], Lucyna Grządziel[a],

[a] *Institute of Physics – CSE, Silesian University of Technology, Konarskiego 22B, 44-100 Gliwice, Poland*
E-mail: karolina.mertin@polsl.pl

Keyword: conductive polymer, polyaniline, degradation factors, X-ray, UV light

Conductive polymers are characterized by extended π-conjugated systems with a high degree of electron delocalization. Among these, polyaniline (PANI) stands out due to its tunable electrical conductivity, ease of synthesis, and environmental stability. These attributes make PANI highly suitable for a broad spectrum of applications, notably in various sensor technologies, including gas sensors, biosensors, pH sensors, and temperature sensors.

Recent research into the integration of PANI within organic electronic devices has highlighted that its electrical and electrochemical responses are profoundly influenced by its chemical structure, doping level, and synthesis conditions. Notably, the highest conductivity is achieved in the emeraldine salt form, produced through the protonation of emeraldine base with acids. This protonation process enhances the number of charge carriers and promotes electron delocalization, thereby significantly improving the material's electrical conductivity.

In this study, we investigate how various degradation factors affect the structural and morphological properties of PANI films. Polyaniline was deposited on glass substrates by spin coating method, and the influence of selected external conditions was systematically examined. Specifically, we studied the effects of post-deposition temperature, X-ray exposure, and UV light irradiation on the material. These parameters were chosen due to their relevance in real-world device environments, where PANI-based components may be subjected to elevated temperatures, high-energy radiation during characterization, or prolonged exposure to light.

The resulting samples were analyzed using optical microscopy to observe changes in macroscopic film homogeneity and surface defects, while atomic force microscopy was employed to assess nanoscale surface morphology, roughness, and possible degradation patterns. The comparative analysis of samples under different conditions allowed us to correlate environmental stressors with changes in surface structure and stability of the PANI films. Understanding these relationships is crucial for optimizing the performance and durability of PANI-based electronic devices, particularly in applications that require long-term operational reliability under varying environmental conditions.

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Mesomorphic study of nanocomposites of liquid crystals

Poornima Bhagavath, Priya Angadiyavar

Department of Chemistry, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, Karnataka, India
E-mail: poornishashi@gmail.com

Keyword: Liquid crystals, nanocomposites.

Liquid crystal discovery has led to the fabrication of many functional materials with varied anisotropies of molecular matter combining with their dynamic nature. Its anisotropic nature allows it to respond to electric and magnetic properties, making it a highly researched domain. Integrating nanoparticles into liquid crystals has emerged as a contemporary research domain in soft matter. The interplay between the two can substantially transform their properties and dynamics. Dispersion of nanoparticles such as carbon nanotubes, zinc oxide nanoparticles, gold nanoparticles, etc. has improved the electro-optical properties of the liquid crystal, such as faster response, low threshold, and non-volatile memory.

In the present work, liquid crystals are prepared by a combination of Schiff base and substituted benzoic acid resulting in supramolecular hydrogen-bonded compounds. The nanocomposites of these compounds are obtained by doping variety of nanoparticles such as metal, metal-oxide and CNTs in varying weight percentages. The mesomorphic behaviour of the nanocomposites are studied and the results are interpreted.

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Biopolymer nanocomposite as a potential corrosion inhibitor for mild steel in acid medium

Preethi Kumari P[a], Divya Nayak[a]

[a] *Department of Chemistry, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, Karnataka, India*
E-mail: preethi074@gmail.com

Keyword: Guar gum, graphite oxide, nanocomposite, impedance, hydrochloric acid

The nanocomposite of exfoliated graphite oxide (xGO) and guar gum (GG) biopolymer was synthesized and characterized using FTIR, while its morphology was analyzed through optical microscopy, SEM, and EDX techniques. The corrosion inhibition efficiency of the xGO/GG nanocomposite was evaluated at varying concentrations and temperatures using electrochemical methods, including potentiodynamic polarization (PDP) and electrochemical impedance spectroscopy (EIS).

The results demonstrated that xGO/GG nanocomposite acts as an effective ecofriendly corrosion inhibitor for mild steel (MS), achieving an inhibition efficiency of 80 % at a concentration of 0.5 g/L (500 ppm). A proposed inhibition mechanism, supported by thermodynamic parameter calculations, explains the adsorption behavior of xGO/GG on the MS surface. Additionally, SEM and AFM analyses confirm the successful adsorption of the nanocomposite, further validating its protective effect.

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Eco-Friendly Inhibitor for Corrosion Protection of 6061 Al Alloy in Acidic Environments

Suma A Rao[1*], Namitha Kedimar[1], and Padmalatha Rao[1,2]

[1]*Department of Chemistry, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, Karnataka, INDIA*

[2]*Department of Chemistry, Nitte Meenakshi Institute of Technology, Bengaluru, Karnataka, INDIA.*

Corresponding author email: suma.rao@manipal.edu

Keyword: 6061 Al-10vol% SiC; adsorption; acid corrosion; surface morphology; DFT studies

The eco-friendly ionic liquid 1-methyl-1-propylpiperidinium bromide (MPPB) was employed as a surface modifier on the nanoscale to enhance the corrosion resistance of 6061Al alloy in HCl. Electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization (PDP) techniques were used to evaluate the inhibition efficiency in the temperature range of 303–323 K. The results indicate that MPPB forms a nanostructured protective layer on the specimen surface through physisorption, following the Langmuir adsorption isotherm. The inhibition efficiency of MPPB decreased with increase in temperature and increased with increase in its concentration, achieving a maximum efficiency of ~73% at 400 ppm and 303 K. Kinetic and thermodynamic studies confirmed the interactions between MPPB and 6061 Al alloy. Surface characterization using scanning electron microscopy(SEM), atomic force microscopy (AFM), and energy dispersive x-ray (EDAX)revealed the formation of a uniform corrosion-resistant nano-coating, reducing metal degradation in acidic environments. This study highlights the potential of ionic liquid-based surface modifiers as sustainable and efficient corrosion inhibitors, contributing to environmentally friendly surface protection strategies for industrial applications.

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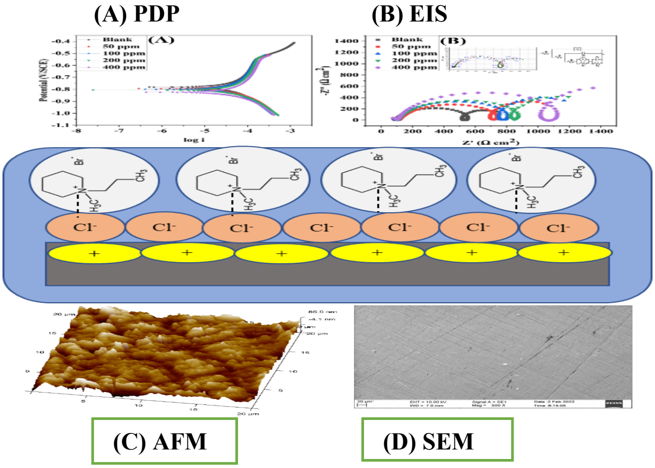

Role of nano-domain and omega phase on the superelasticity of Ti-Zr-Nb-Sn alloys for biomedical applications

Tae-hyun Nam, Jinhwan Lim

Department of Materials Engineering and Convergence Technology and RIGET, Gyeongsang National University, Korea
E-mail: tahynam@gnu.ac.kr

Keyword: Ti-Zr-Nb-Sn alloys, nano-domain, omega phase, superelasticity

Microstructure, superelastic and mechanical performances of a Ti–40Zr–8Nb–2Sn (at.%) shape memory alloy aged at 300°C for 1 h by means of trasmission electron microscopy, X-ray diffraction and cyclic tensile tests. The quite fine nano-scaled ωiso phases were formed in the aged high Zr-containing Ti–40Zr–8Nb–2Sn (at.%) alloy. The dimension of isothermal omega phases was 2.1–2.9 nm wide and 2.9–4.4 nm long. In addition to ωiso phases, nanodomains were also observed in the aged alloy. Excellent superelasticity with a large total recovery strain of 7.1%, enhanced yield stress of 578 MPa, and large ductility of 11.6% were achieved in the aged alloy, which is mainly due to the age hardening effect caused by the quite fine nano-scaled ωiso phases. Stress inducedβ → α'' martensitic transformation occurred in the aged alloy during loading although it contained nanodomains. These desirable mechanical properties and superelasticity were related to the high Zr effect leading to quite fine nano-scaled ωiso phases.

Selectively Oxidized Schizophyllan as a Template for the Synthesis of Gold Kite-like Nanostructures

Vítek Hrbáček[a], Jan Vícha[a], Lukáš Münster[a]

[a] *Centre of Polymer Systems, Tomas Bata University in Zlín, tř. Tomáše Bati 5678, 760 01 Zlín, Czech Republic*

E-mail: v_hrbacek@utb.cz

Keywords: *Schizophyllan, Periodate oxidatoin, Template-assisted synthesis, Gold nanostructures, Catalysis*

This study presents a novel approach for synthesizing gold nanostructures with a unique kite-like morphology (AuSCH), enabled by the selective oxidation of schizophyllan. Schizophyllan is a high-molecular-weight polysaccharide composed of a (1→3)-β-ᴅ-glucan backbone with (1→6)-β-ᴅ-glucopyranosyl side chains at every third glucose unit. In nature, it adopts a rigid, triple-helix conformation. Upon selective oxidation and exposure to a gold precursor solution at elevated temperatures, spontaneous formation of AuSCH occurs. These unique nanostructures consist of a thin nanowire tail, 5–10 nm in diameter and up to 150 nm in length, terminated by a larger, faceted nanoparticle approximately 20–50 nm in diameter. Unlike previous approaches that rely on the denaturation and subsequent renaturation of schizophyllan triple-helix to trap preformed gold nanoparticles within its narrow hydrophobic cavity (Bae et al. 2007), our method employs selective oxidation of the side chain with sodium periodate to introduce aldehyde groups on the outer surface of the helix. These functional groups participate in a redox reaction with gold(III) ions, facilitating the template-assisted growth of anisotropic nanostructures on the exterior of helixes. This strategy is not only more direct and efficient but also enables near-quantitative yields, with the added benefit of recyclable oxidants. The synthesized AuSCH structures exhibit excellent catalytic activity, demonstrated by the model reduction of 4-nitrophenol to 4-aminophenol in the presence of sodium borohydride. Furthermore, the anisotropic morphology of these nanostructures suggests promising potential for sensing applications.

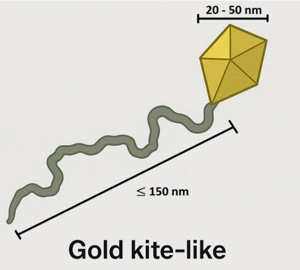

Figure 1- The graphical representation of prepared gold nanoparticles

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Effect of organic cations on optical and electrical properties of bismuth iodide complexes in memristive devices

Gisya Abdi[a], Abdolhamid Alizadeh[b], Konrad Szaciłowski[a]

[a]*Academic Centre for Materials and Nanotechnology, AGH University of Krakow, al. Mickiewicza 30, Kraków, 30–059 Poland*
[b]*Department of Organic Chemistry, Faculty of Chemistry, Alzahra University, Tehran 1993893973, Iran*
E-mail: agisya@agh.edu.pl

Keyword: Neuromorphic computing, Memristors, Perovskites-like semiconductors

Traditional von Neumann computing faces limitations due to the memory bottleneck, especially in AI applications. While CMOS-based neuromorphic chips offer energy-efficient parallel processing, their scalability is constrained by size and fabrication complexity. Memristive devices present a promising alternative, with simple structures, high integration density, and compatibility with diverse materials.

Among these, low-dimensional bismuth halide hybrids have emerged as lead-free alternatives to toxic perovskites (Figure 1). They offer chemical stability, low toxicity, and tunable properties ideal for memristive devices in sustainable neuromorphic applications.[1-4] Organic cations in these hybrids play a key role in defining the dimensionality and structure, thereby influencing optical and electrical behaviors. By modulating layer spacing, dielectric environment, and defect states, organic cations enable control over bandgap, exciton binding, charge transport, and resistive switching performance. This structural and electronic tunability makes bismuth-based hybrids a versatile platform for next-generation memristive and neuromorphic devices.

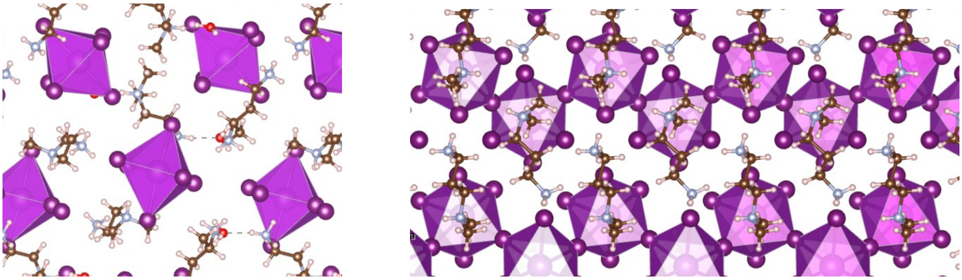

Figure 1. *(a) 0D fragments and (b) 1D fragments of Bi-I octahedron in crystal structures of BiI$_3$ complexes*

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Defect-induced modulation of band alignment in phthalocyanine layer on oxygen-deficient ZnO substrates

Sakineh Akbari Nia[a*], Aleksandra Przybyła[a], Mieczysław A. Pietrzyk[b], Paulina Powroźnik[a], Maciej Krzywiecki[a**]

[a] *Institute of Physics – CSE, Silesian University of Technology, Konarskiego 22B, 44-100 Gliwice, Poland.*
[b] *Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, PL-02668, Warsaw, Poland.*
*E-mail: *Sakineh.akbarinia@polsl.pl*
***Maciej.krzywiecki@polsl.pl*

Keyword: Hybrid layer, zinc oxide, phthalocyanine, oxygen vacancy, energy alignment, charge transfer.

Zinc oxide (ZnO) as a transparent semiconductor oxide and metal phthalocyanines (MPcs) as planar conjugated molecules are progressively introduced to low-cost small molecular organic electronic and optoelectronic devices such as sensors and solar cells. Despite their combined application, a comprehensive understanding of the electronic interaction at their interface is missing. From this perspective, our research addresses this critical gap by considering the interface formation between ZnO substrates with different concentrations of oxygen vacancies)O_{vac}), and the MPc molecular layer.

In this study, we seek the diverse interactions caused by the induced O_{vac}, especially focusing on the variation of the O_{vac} concentration achieved through controlled defect implantation. To create the interface, the ZnO layer was deposited by applying a plasma-assisted molecular beam epitaxy technique, then the MPc molecular powder was sublimated from resistively heated crucibles in an ultra-high vacuum chamber to deposit ~ 8.8 nm molecular layer in a stepwise manner. Controlled by oscillating quartz microbalance, the sublimation rate was 0.03 Å/s.

Utilizing in-situ X-ray/ultraviolet photoelectron spectroscopy (XPS/UPS) and scanning tunnelling microscopy (STM), we are characterizing and reporting the electronic structure and morphology of the oxygen-deficient ZnO/MPc hybrid layer as inorganic/organic semiconductor hybrid structure. Especially, we investigate the impact of the controlled O_{vac} implanted on the ZnO surface on the electronic properties of the ZnO/MPc interface, including the variation of the interfacial dipole, work function evolution, energy level alignment, and potential charge transport caused by the most subjected orbitals.

This work offers valuable insight into the role of O_{vac} at ZnO/MPc interfaces, which is highly important for designing and fabricating high-performance optoelectronic devices.

Session: Catalysis for Clean Energy and Chemical Production

Invited Lectures

Regular Lectures

Poster Presentations

Highly effective hydrodeoxygenation catalysts obtained from transition-metal-containing layered double hydroxide precursors

Claudiu Rizescu[a], Alexandru-Tudor Toderaşc[a], Adriana Urdă[a], Ionel Popescu[b], Ioan-Cezar Marcu[a]

[a] *Laboratory of Chemical Technology and Catalysis, Department of Inorganic and Organic Chemistry, Biochemistry and Catalysis, Faculty of Chemistry, University of Bucharest, 4-12, Blv. Regina Elisabeta, 030018, Bucharest, Romania*
[b] *Laboratory of Chemical Technology and Catalysis, Division of Exact Sciences, Research Institute of the University of Bucharest (ICUB), 90, Panduri Street, 050663 Bucharest, Romania*
E-mail: ioancezar.marcu@chimie.unibuc.ro

Keyword: Bio-oil, Catalytic Upgrading, Hydrodeoxygenation, Mixed Oxides, Layered Double Hydroxide

The oxygen-containing bio-oil obtained by the flash pyrolysis of lignocellulosic biomass has a high oxygen content with negative consequences on its properties: chemical instability, high acidity, high viscosity and low heating value [1]. Catalytic hydrodeoxygenation (HDO) is a method of choice for bio-oil upgrading, consisting in the conversion of oxygen-containing compounds into hydrocarbons via hydrogenolysis of C–O bonds at medium temperatures (250-450 °C) and pressures (80-200 bar). The sulphides and the noble metals are among the most active catalysts for this process [1]. However, the first suffer from deactivation due to transformation of sulphide into oxide in time, while the second are very expensive. Non noble metal-based catalysts represent an attractive alternative.

Layered double hydroxides (LDH) or hydrotalcites are anionic clays having the general formula $[(M^{2+})_{1-x}(M^{3+})_x(OH)_2]^{x+}(A^{n-})_{x/n}\cdot mH_2O$ with $0.2 \leq x \leq 0.4$, in which M^{2+} and M^{3+} are bivalent and trivalent cations, respectively, with ionic radii close to that of Mg^{2+}. Thermal decomposition of the transition-metal-containing LDH leads to homogeneous mixed oxide structures with relatively high surface areas, good thermal stabilities and tunable acid-base and redox properties, which make them attractive multifunctional catalysts for different processes, including hydrodeoxygenation [2].

A series of ex-LDH M-MgAlO mixed oxide catalysts with Mg/Al = 3 and 10 at. % M with respect to cations (M = Mn, Fe, Co, Ni, Cu and Zn), was studied in the HDO reaction of benzyl alcohol as a model oxygenated compound. Among them, the Cu-containing system showed the best catalytic performance and, hence, the Cu content was varied in the range from 5 to 20 at. %. With ca. 95 % alcohol conversion and ca. 90 % toluene selectivity in standard reaction conditions, *i.e.*, 50 mg catalyst, 230 °C, 5 atm H_2, 3 h reaction time, the mixed oxide with 15 at. % Cu was the best catalyst in this series [3]. Furthermore, the effect of the acid-base properties on the performance of Cu-MgAlO system was studied by varying the Mg/Al molar ratio in a series with 15 at. % Cu and Mg/Al = 0/1, 1/1, 3/1, 5/1, and 1/0 [4]. The catalysts with Mg/Al molar ratios of 3/1 and 5/1, issued from well-crystallized LDH precursors, exhibited the highest activity, with toluene yields higher than 85 %. It has been shown that the alcohol conversion follows the basicity of the catalysts in this series, while the HDO selectivity follows their acidity. Alternatively, a series of Cu-containing catalysts with different Cu contents in the range from 2.5 to 20 at. % was prepared from LDH precursors in which Al was replaced by Fe (Mg/Fe mol ratio of 3). In this series, the system with 10 at. % Cu gave the best results: 94 % alcohol conversion with 94 % selectivity to toluene in standard conditions [5]. Compared to Cu-MgAlO catalysts, in which Al^{3+} species are not reducible, in the Cu-MgFeO systems the presence of Fe favors the formation of oxygen vacancies resulting in better activity at lower Cu content.

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Steering the reversible metal cluster formation in working electrocatalysts with subnanometer accuracy

Janis Timoshenko[a], Beatriz Roldan Cuenya[a],

[a] *Interface Science Department, Fritz Haber Institute of Max Planck Society, Faradayweg 4-6, Bertlin 14195, Germany*

Keyword: Operando X-ray aborption spectroscopy, Electrocatalysis, Metal clusters

Unravelling the structure-properties relationships remains one of the open problems in the studies of functional nanomaterials, and heterogeneous electrocatalysis in particular. It is especially true for such complex multielectron reactions as electrocatalytic CO_2 reduction (CO_2RR). One of the reasons for that is the dynamic transformation of the electrocatalyst's active species under working conditions, which are hard to account for using available theoretical approaches, and are also often hard to predict from the ex-situ measurements of the as-prepared pre-catalysts. Such transformations can be especially elusive, if they are at least partially reversible, making the post-mortem analysis of the catalyst inconclusive, and limiting severely the set of experimental tools that can be used for their investigation. On the other hand, if such dynamic, reversible transformations can be reliably tracked by *operando* methods, and, importantly, also steered on demand, this would provide one with truly unique opportunity for tailoring on-the-fly the catalyst structure and functionality, allowing one to efficiently explore complex parameter spaces and disentangle contributions of the different species coexisting in the heterogeneous electrocatalysts.

Here we demonstrate that the transition metal and nitrogen co-doped carbon (TMNC) catalysts are an excellent platform for this purpose. In particular, we show that the control over the reversible formation and fragmentation of catalytically active metallic Cu clusters in the Cu-based TMNCs can be achieved by means of pulsed reaction protocols, where the chemical state and, crucially, also particle size of the catalyst can be tuned by simply changing the durations of the applied anodic and cathodic potential pulses. Furthermore, the evolution of the catalyst structure can be tracked by synchrotron-based quick XAFS spectroscopy (QXAFS). The combination of pulsed electrocatalysis with operando QXAFS allows us to investigate in detail the role of particle size on CO_2RR functionality, focusing on the regime of subnanometer particle sizes which has been so far challenging to explore. Specifically, we demonstrate that for the ultrasmall metallic clusters, their catalytic properties cannot be simply extrapolated from those of larger metal nanoparticles, nor from those of singly dispersed cationic sites. We show that while the nanometer-sized Cu nanoparticles convert CO_2 mostly to CO, and singly dispersed cationic Cu favors hydrogen evolution over CO_2RR, the ultrasmall metal clusters which can be stabilized under dynamic pulsed conditions with optimized pulse durations show the high selectivity for methane production [1].

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Phosphide-Based Nanocatalysts: Tuning Composition and Interfaces for Next-Generation Electrochemical Conversion

M. Bar Sadan

The Chemistry Department, Ben Gurion University of the Negev, Beer Sheva, Israel
E-mail: barsadan@bgu.ac.il

Keywords: MOR; HER; UOR; bimetallic structures; electrocatalysis;

Transition metal phosphides (TMPs) are emerging as a powerful class of materials for electrochemical catalysis, combining earth abundance with promising activity in both energy conversion and selective organic oxidation reactions. This talk will present a series of research efforts focused on the rational design of TMP-based nanostructures, emphasizing how composition tuning, phase control, and interface engineering can significantly improve catalytic performance. A major challenge in this field lies in the controlled synthesis of well-defined, stable structures—particularly for bimetallic phosphides. Achieving reproducible architectures that allow meaningful structure–property correlations remains nontrivial, especially as many systems undergo dynamic reconstruction under working conditions.

We address these challenges through a comparative study of nickel, cobalt, and copper phosphides, in both mono- and bimetallic forms. These materials are evaluated in two key reaction classes: hydrogen evolution (HER) and the electrooxidation of small organic molecules such as alcohols and urea. We demonstrate that strategies such as tungsten doping in $Ni_{12}P_5$, vacancy-guided cation exchange in Cu–Co systems, and in situ formation of heterostructures all contribute to enhanced reactivity, selectivity, and long-term stability. Several of these catalysts show high selectivity for the conversion of methanol and ethanol into value-added products like formate. This bifunctional behavior highlights the versatility of TMPs and their potential role in integrated energy and chemical production schemes.

The presentation will integrate synthetic approaches with mechanistic insights. Together, these efforts outline a roadmap for the advancement of noble-metal-free, multifunctional electrocatalysts tailored for sustainable technologies.

Our Advanced Characterization Platform for Studying Nanostructured Materials as Electrocatalysts for Fuel Cells and Electrolyzers

Nejc Hodnik[a,b]

[a] *National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia*
[b] *Institute of Metals and Technology, Lepi Pot 11, 1000 Ljubljana, Slovenia*
E-mail: nejc.hodnik@ki.si

Keyword: Electrocatalysis, Fuel Cell, Electrolysis, Advanced Electrochemical Characterization, IL-TEM

Nanostructured electrocatalysts are central to energy conversion technologies such as fuel cells, electrolyzers, and CO_2 reduction systems. However, their performance and long-term stability are strongly influenced by structural dynamics under operating conditions. In this talk, I will present our set of advanced characterization techniques that provide direct insight into catalyst degradation and transformation pathways [1].

Using Identical Location Transmission Electron Microscopy (IL-TEM), 4D-STEM, and machine learning, we track atomic-level changes in individual nanoparticles before and after electrochemical operation. [2] These methods are integrated into the Nano Lab platform, which combines catalyst synthesis, electrochemical testing, and high-resolution imaging [3]. To ensure application relevance, we also employ modified floating electrode setups and an electrochemical flow cell–ICP-MS for real-time, high-throughput, and element-specific analysis [4, 5].

This integrated approach bridges fundamental nanoscale understanding with industrial application. By generating critical feedback on structural and chemical changes during electrocatalyst lifetime, our methodology accelerates the development of more robust and efficient electrocatalyst materials.

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Hybrid Catalytic Systems for Electrochemical Conversion of Inert Inorganic Molecules: Reduction of Carbon Dioxide and Nitrogen

Pawel J. Kulesza, Iwona A. Rutkowska Anna Chmielnicka, Beata Rytelewska, Olena Siamuk, Ilia Smirnov

Faculty of Chemistry, University of Warsaw, Pasteura 1, PL-02-093 Warsaw, Poland
E-mail: pkulesza@chem.uw.edu.pl

There has been growing attention in the electrochemical reduction of carbon dioxide, a potent greenhouse gas and a contributor to global climate change. Given the fact that the CO_2 molecule is very stable, its electroreduction processes are characterized by large overpotentials. To optimize the hydrogenation-type electrocatalytic approach, we have proposed to utilize nanostructured metallic centers (e.g. palladium) in a form of highly dispersed and reactive nanoparticles generated within supramolecular network of distinct nitrogen, sulfur or oxygen-coordination complexes. Among important issues are the mutual completion between hydrogen evolution and carbon dioxide reduction and specific interactions between coordinating centers and metallic sites. We have also explored the ability of biofilms to form hydro-gel-type aggregates of microorganisms attached to various surfaces including those of carbon electrode materials. Upon incorporation of various noble metal nanostructures and/or conducting polymer ultra-thin films, highly reactive and selective systems toward CO_2-reduction have been obtained. Another possibility to enhance electroreduction of carbon dioxide is to explore direct transformation of solar energy to chemical energy using transition metal oxide semiconductor materials. We show here that, by intentional and controlled combination of metal oxide semiconductors (Cu-intercalated tungsten(VI) oxide and copper(I) oxide), we have been able to drive effectively photoelectrochemical reduction of carbon dioxide mostly to methanol.

Application of metal oxides as active matrices in electrocatalysis is particular importance. The hydrous behavior, which favors proton mobility and affects overall reactivity, reflects not only the oxide's chemical properties but its texture and morphology as well. For example, the mixed oxide (WO_3 and ZrO_2) systems are characterized by fast charge (electron, proton) propagation during the system's redox transitions. By dispersing metallic Cu electrocatalytic nanoparticles over such active WO_3-based supports, the electrocatalytic activities of the respective systems toward the reduction of carbon dioxide have been enhanced even at decreased loadings in acid media. The fact that the oxide nanostructures are in immediate contact with the metallic catalytic sites leads to the specific interactions (via the surface hydroxyl groups) with the reaction intermediates (e.g. CO adsorbates).

Formation of ammonia is one of the most important chemical synthetic processes. Under industrial conditions, ammonia is primarily been synthesized from nitrogen and hydrogen via the Haber-Bosch process which requires pressurizing and heating, despite utilization of catalysts. Consequently, development of low-temperature synthetic methodology is tempting both from the practical and fundamental reasons. An ultimate goal for electrochemistry is to generate NH_3 from N_2 at temperatures lower than 100ºC, atmospheric pressure, and with use of new generation of catalysts. Currently, most of electrochemical approaches to drive N_2-fixation suffer from slow kinetics due to the difficulty of achieving the appropriate adsorption and activation of dinitrogen molecule leading to cleavage of the strong triple N≡N bond. Our recent studies, clearly demonstrate that coordinatively stabilized iron catalytic sites, e.g. iron-centered heme-type porphyrins or iron phosphides, have been found to act as efficient catalysts for the formation of NH_3 in alkaline and semi-neutral media.

Tailored Polymer Nanoparticles for Heterogeneous Asymmetric Organocatalysis and Transition Metal Catalysis

Inés Adam-Cervera[a], Alberto Llopis-Lacruz[a], Francisco F. Pérez-Pla[a],
María González-Béjar[b], Rafael Muñoz-Espí[a],*

[a] *Institute of Materials Science (ICMUV), University of Valencia, Paterna, Spain*
[b]*Institute of Molecular Science (ICMol), University of Valencia, Paterna, Spain*
E-mail: rafael.munoz@uv.es

Keywords: miniemulsion, colloid, asymmetric catalysis, nanoparticle

The incorporation of catalytically active organic and metallorganic moieties into polymer nanoparticles is a powerful strategy for designing efficient, sustainable heterogeneous catalysts. Functionalized polymer supports enhance catalytic performance by improving active site accessibility and structural stability. Miniemulsion polymerization, known for its efficiency and versatility, enables the preparation of nanoparticles with controlled size, morphology, and high surface area, key factors for optimizing catalytic activity [1].

This work presents the synthesis of polymer nanoparticles by miniemulsion polymerization and their surface functionalization with catalytic ligands, including proline derivatives, Schiff-base metal complexes, and xanthene-derived fluorophores. The approach involves copolymerizing a structural monomer (typically styrene or methyl methacrylate) with a catalytically active functional comonomer. For proline-based nanoparticles, the structural monomer was copolymerized with specially synthesized polymerizable catalytically active comonomers [2]. A similar strategy was used for Schiff-based systems, with the ligand complexed in this case with Mn(III). In xanthene-based catalysts, rhodamine B was reacted with 2-hydroxyethyl methacrylate (HEMA) via a Steglich esterification to yield an ester-functionalized comonomer for radical polymerization. Nanoparticles were synthesized using styrene, divinylbenzene, and the rhodamine B-derived comonomer.

Following functional comonomer synthesis and nanoparticle preparation, catalytic activity was assessed in selected organic reactions. Proline-functionalized nanocatalysts showed high diastereoselectivity in the intermolecular aldol reaction between p-nitrobenzaldehyde and cyclohexanone in water. Schiff-base systems efficiently catalyzed the asymmetric epoxidation of styrene and indene, with reaction kinetics analyzed by chiral column chromatography. All catalytic systems achieved substrate conversion of at least 90%, with sterically hindered catalysts exhibiting the highest selectivity and reaction yields exceeding 99% after 24 hours. Xanthene-containing nanoparticles proved highly effective photocatalysts for the dehalogenation of meso-1,2-dibromo-1,2-diphenylene. A key advantage of these catalytic systems is their ease of separation and recyclability, supporting their potential for sustainable applications.

Acknowledgements: We acknowledge financial support from the Generalitat Valenciana (Consolidated Group Grant No. CIAICO/2023/172 and MFA/2022/064) and from the Ministry of Science and Innovation of Spain (Grant No. PID2023-152347OB-I00)

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Electrochemical pH sensing at electrified interfaces and in levitating droplets using ultra micro electrodes

Isabell Wachta[a], Wei Nie [b,c], Gloria Alexander [a], Christopher S. Kley [b,c], Kannan Balasubramanian[a]

[a] Department of Chemistry and School of Analytical Sciences Adlershof (SALSA), Humboldt-Universität zu Berlin, 10099 Berlin, Germany
[b]Helmholtz Young Investigator Group Nanoscale Operando CO2 Photo-Electrocatalysis, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, 14109 Berlin, Germany
[c] Department of Interface Science, Fritz-Haber-Institut der Max-Planck-Gesellschaft, 14195 Berlin, Germany
E-mail: isabell.wachta@hu-berlin.de

Keywords: Local pH, Alternating current voltammetry, pH sensor, Ultramicroelectrode

Information about local pH is crucial for the elucidation of reaction mechanisms in several applications such as electrocatalysis, biology and corrosion. [1,2] There are many miniaturized pH sensors reported. [3] However, present sensing systems suffer from long response times. We first show a simple strategy to fabricate a gold ultramicroelectrode. Such an electrode was modified with polymethylene blue to realize a fast voltammetric pH micro sensor with a sensitivity of 65 mV/pH for a pH range of 0.5 – 7.2. Investigating interfacial processes occurring at electrified interfaces is a niche application in electrocatalysis. In a proof-of-concept measurement, we could detect interfacial pH changes at an electrified platinum nanoparticle-modified carbon electrode during the hydrogen and oxygen evolution reactions with a sub-second resolution using alternating current voltammetry.[4] pH micro sensors are also helpful for performing electrochemical measurements in small volumes like levitating droplets. Reactions occurring in these microreactors are known to show enhanced kinetics. Observing such processes provides valuable analytical information about different reactions. [5] We demonstrate the feasibility to follow enzymatic reactions and detect volatile organic compounds dissolved in levitating droplets using the monitored pH changes.

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Designing Next-Generation $SrTiO_3$ Perovskite Catalysts: Exsolution Strategies for Boosting Oxygen Evolution Reaction Efficiency

Kimia Jafari[a], Micah Soriano[a], Sarah Geo[b], Athanasios Chatzitakis[b], Dragos Neagu[a]

[a] *Department of Chemical and Process Engineering, University of Strathclyde, G1 1XL Glasgow, The United Kingdom*
[b] *Department of Chemistry, Centrefor Materials Science and Nanotechnology, University of Oslo, NO-0349 Oslo, Norway*
E-mail: Kimia.jafari@strath.ac.uk

Keyword: Perovskites, Exsolution, Electrocatalyst, Oxygen Evolution Reaction, Transition Metal Nanoparticles

The urgent need for efficient and sustainable energy conversion technologies has propelled the search for robust and cost-effective electrocatalysts for the oxygen evolution reaction (OER), which is a critical step in water splitting and renewable energy storage. Perovskite oxides, particularly those from the $SrTiO_3$ family, have emerged as promising candidates due to their tunable electronic structures, high catalytic activity, and exceptional stability under alkaline conditions. In this study, we systematically investigate the OER performance of $SrTiO_3$-based perovskite catalysts, with a particular focus on the impact of elemental doping, defect engineering, and controlled exsolution of nanoparticles. Through nanoparticle exsolution, metal nanoparticles are efficiently created predominantly at the surface of an oxide matrix (electrode).

Our approach combines synthesising perovskites through sol-gel method, extracting and comparing cell parameter, crystallite size, microstration, nanoparticle size and population using X-ray diffraction (XRD), and scanning electron microscopy (SEM), and evaluating catalytic performance by electrochemical methods (cyclic voltammetry and linear sweep voltammetry) to elucidate how active sites behave during the OER.

Through precise A-site and B-site doping strategies, we demonstrate how tailored modifications in key structural metrics, including crystallite size, microstrain, nanoparticle size, and population, promote the exsolution of catalytically active transition metal nanoparticles (i.e., Cu, Ni, Fe, and Co) under controlled experimental conditions. Electrochemical characterisation further elucidates the role of these structural modifications in governing active site evolution and catalytic efficiency for the OER. The results reveal that the exsolved metal nanoparticles play a crucial role in enhancing reaction kinetics and electron transfer.

The insights gained from this study provides a fundamental understanding of structure-activity relationships in $SrTiO_3$-based perovskites and open new avenues for designing next-generation OER catalysts with superior activity, stability, and cost-effectiveness. These findings not only advance the field of perovskite electrocatalysis but also contribute to the broader development of sustainable energy conversion technologies.

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Electrospun nanofiber mats: a new class of supports with high porosity

P. Topka, K. Soukup, J. Kupčík, J. Balabánová, M. Koštejn, O. Šolcová

Institute of Chemical Process Fundamentals of the Czech Academy of Sciences,Praha, Czech Republic
E-mail: topka@icpf.cas.cz

Keyword: Electrospinning, Nanofiber mats, Catalyst Supports, Oxidation, Volatile Organic Compounds

Structured catalysts with high porosity are particularly suitable for industrial processes carried out at high space velocities. One of these processes is catalytic total oxidation of volatile organic compounds, which is economically feasible and environmentally friendly way of emission abatement. Designing catalysts with low amount of active phase is important for industrial applications [1].

In this work, Pt nanoparticles were deposited on electrospun polybenzimidazole mat. By tuning the preparation conditions, catalysts with different Pt loading and particle size were obtained. The Pt active sites were deposited on the surface of nanofibers (Fig. 1) and were readily accessible to the reactants. As a result, the catalyst containing only 0.08 wt.% of Pt was able to reach a high conversion (90 %) of model VOCs (toluene, acetone, ethanol) at moderate temperatures (from 229 °C to 334 °C).

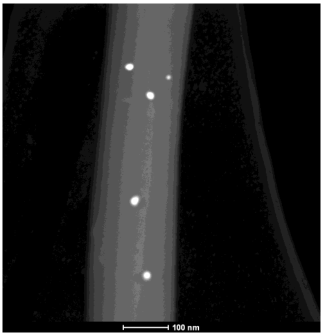

Fig. 1. STEM image of Pt nanoparticles supported on polybenzimidazole nanofiber mat.

Furthermore, we have shown that the TOF depends on the size and type of Pt nanoparticles. The catalysts with Pt particle sizes 1.5 nm and 26 nm exhibited lower catalytic activity than that with Pt particle size of 12 nm. The catalysts with Pt particle size 1.5 nm and 12 nm were prepared by equilibrium adsorption and the higher catalytic activity of the latter catalyst can be explained by the decrease of the Pt–O bond strength with the enlargement of the Pt particle size, which led to more reactive adsorbed oxygen on Pt sites. On the other hand, the catalyst with Pt particle size 26 nm was prepared by solvent evaporation method and contained polycrystalline platinum. Thus, although the Pt particle size determined by TEM was 26 nm, the size of single coherent domains was lower, which correlated with the lower catalytic activity of this catalyst.

Acknowledgement:
This work was supported by the Technology Agency of the Czech Republic (project TN02000044).

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Electrochemical Plasmonic Sensing at the Graphene-Electrolyte Interface

Robert Jungnickel Berlin/Germany, Kannan Balasubramanian Berlin/Germany

Humboldt-Universität zu Berlin, Department of Chemistry & School of Analytical Sciences Adlershof (SALSA), Unter den Linden 6, 10099 Berlin, Germany
E-mail: robert.jungnickel@hu-berlin.de

Keyword: surface plasmon resonance, plasmon waveguide resonance, graphene, hexagonal boron nitride, electrochemistry, nanoparticles

The coupling of surface plasmon resonance (SPR) sensing techniques with electrochemistry is a promising analytical framework for the investigation of potential-driven phenomena at the solid-liquid interface of 2D materials (2DMs). [1] The plasmonic readout in such a configuration allows for in-situ monitoring of electrochemical modifications of the electrode surface. [2] Two major problems regarding this approach arise from the influence of the underlying metal, typically gold, used for the generation of the surface plasmon polaritons: 1. The potential driven change in electron density at the gold-surface causes a huge unwanted background signal obscuring the signal from the analyte. 2. The potential window of a 2DM like graphene is largely diminished by the redox-activity of the underlying gold film. Here, we present two device architectures that utilize graphene as the electrochemical interface, while decoupling it from the plasmonic metal substrate. This helps us to exclusively observe electrochemical processes using the plasmonic signals. In the first approach, a van der Waals heterostructure composed of graphene and hexagonal boron nitride (hBN) is transferred onto a gold SPR sensor, effectively eliminating background plasmonic signals from the metal and enabling unambiguous interpretation of redox reactions. [2] In the second approach, a dielectric polymer waveguide on gold supports plasmon waveguide resonance (PWR), with a graphene electrode placed on top. [3] These platforms allow for the in-situ observation of processes such as the growth, dissolution, and oxidation/reduction of nanoparticles. Moreover, the data reveal subtle differences between the voltammetric and the plasmonic signals, which can be attributed to the diffusive nature of redox-analytes. We hope that these strategies can help to position electrochemical plasmonic sensing with 2DMs as a versatile tool for mechanistic studies in sensing and electrocatalytic applications.

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Utilization of α-Fe_2O_3 Thin Films in Photoelectrochemical Oxidation Studies

Saim Emin[1,*], Manel Machreki[1], Artem Badasyan[1], Dušan Žigon[2], Georgi Tyuliev[3], Takwa Chouki[1], Qian Guo[4], Ana Belén Jorge Sobrido[4], Stoichko Dimitrov[5]

[1]Materials Research Laboratory, University of Nova Gorica, Ajdovscina 5270, Slovenia.
[2]Institute "Jožef Stefan", Jamova 39, 1000, Ljubljana, Slovenia
[3] Institute of Catalysis, Bulgarian Academy of Science, Sofia 1113, Bulgaria.
[4]School of Engineering and Material Science, Queen Mary University of London, E1 4NS London, U.K.
[5]School of Physical and Chemical Sciences, Queen Mary University of London, E1 4NS London, U.K.
**Corresponding author. E-mail address: saim.emin@ung.si (S. Emin)*

Keywords: α-Fe_2O_3 thin films, 2-(4-isobutylphenyl)propanoic acid and glycerol, photoelectrochemical oxidation.

Porous Sn-doped α-Fe_2O_3 (Sn:Fe_2O_3) thin films were employed as versatile catalysts in photoelectrochemical (PEC) processes, including water oxidation, pharmaceutical drug degradation, and biomass-derived alcohol oxidation. These Sn:Fe_2O_3 photoanodes were tested in simulated wastewater treatment, specifically for the PEC removal of the inflammatory drug 2-(4-isobutylphenyl)propanoic acid (IBPA). The films successfully facilitated the PEC degradation of IBPA in the presence of peroxymonosulfate (PMS) under visible light. In addition, Sn:Fe_2O_3 thin films were explored for converting biomass-derived molecules into high-value products via PEC. This method was applied to selectively oxidize propane-1,2,3-triol and 4-hydroxy-3-methoxybenzyl alcohol (glycerol) under visible light. A kinetic model was developed and solved to track the time-dependent formation of these products. This work provides a fresh perspective on designing effective PEC systems for converting biomass into energy and valuable chemicals.

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Spin-Selective Chemistry in the Presence of Chiral Plasmonic Fields

Anastasiia Tulupova[a], Vladislav Buravets[a], Anastasiia Skvortsova[a], Václav Švorčík[a], Oleksiy Lyutakov[a]

[a] *Department of Solid State Engineering, University of Chemistry and Technology, Prague, 16628, Czech Republic*

Keyword: Oxygen evolution, Spin-controlled chemistry, Chiral nanoparticles

The Chiral-Induced Spin Selectivity (CISS) effect has recently emerged as a promising concept in catalysis, offering new strategies for controlling reaction pathways through spin-selective electron transfer. Spin-aligned electrons can promote specific electronic configurations in reaction intermediates or products, thereby lowering reaction barriers, reducing by-product formation and improve the reaction kinetics and yield [1, 2]. For example, in the case of water splitting (oxidation), electron spin alignment supports the triplet oxygen formation, improving in this way reaction kinetic and prohibiting the over undesired hydrogen peroxide [3, 4].

For CISS realisation, the utilization of chiral molecules or layers on the surface of redox-active materials, which allow one to align the spin of transited electrons is commonly used [5]. Alternatively, the creation of “intrinsically chiral” electrodes, for example, using optically active nanomaterials, was proposed to achieve the same goals [6].

In the currently published cases, spin polarization arises from spin–orbit coupling between transient electrons and the specifically organized atoms within chiral materials or organic enantiomers. In this work, we propose an alternative approach to CISS - using a chiral, plasmon-induced electromagnetic field by combining redox-active NiO with chiral Au nanoparticles. Water oxidation was performed in the photoelectrochemical regime, under external bias and plasmon triggering. Performed experiments demonstrate enhanced oxygen evolution reaction and suppression of undesired hydrogen peroxide formation reached due to charge carriers transition through chiral plasmonic field.

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Bilayer Nitrogen-Doped Graphene Electrodes: Minimizing Substrate Effects for Improved Electrochemical Properties

Gloria Alexander Berlin/Germany, Kannan Balasubramanian Berlin/Germany

Humboldt-Universität zu Berlin, Department of Chemistry & School of Analytical Sciences Adlershof (SALSA), Unter den Linden 6, 10099 Berlin, Germany
E-mail: gloria.alexander@hu-berlin.de

Keyword: Graphene, Nitrogen-doping, plasma treatment, electrochemistry, electrocatalysis

Nitrogen doping of graphene is a promising strategy to enhance its electronic and electrochemical properties for electrocatalytic applications.[1] Electrochemical devices based on a single graphene monolayer are often realized on solid supports such as silicon oxide. It is known that the electron transfer (ET) kinetics at graphene with redox-active molecules are dictated by the pH of the solution.[2] This effect is primarily attributed to surface ionizable groups and interfacial charges at the graphene-liquid interface (GLI). The interfacial charge density is also affected by the underlying substrate.[3] We first show that applying a mild nitrogen-plasma treatment leads to a profound alteration of the electrochemical properties including the removal of the dependence of ET on pH. In terms of stability, however, this modification proved to be only transient. To overcome this issue, we have devised a novel bilayer electrode architecture, in which the top layer is modified by nitrogen plasma treatment, while the underlying layer remains pristine. Electrochemical characterization was performed by cyclic voltammetry (CV) using ferricyanide as a redox probe at various pH values, and surface analysis was carried out using Raman spectroscopy and X-ray photoelectron spectroscopy (XPS). Compared to a single-layer graphene electrode, the bilayer architecture demonstrated significantly improved electrochemical stability under varying pH conditions. We attribute this effect to the minimization of surface charge effects from the underlying substrate, which enables a systematic investigation of the electrochemical and electrocatalytic properties of nitrogen-doped graphene. Our results provide new insights into the stability and functionality of nitrogen-doped graphene interfaces and highlight their relevance for future applications in electrocatalysis.

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L-proline catalyzed multicomponent synthesis of pyrano-pyrimidines

Nitinkumar S. Shetty

Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, India-576104
E-mail: nitin.shetty@manipal.edu

The synthesis of fused heterocycles has attracted considerable interest in heterocyclic chemistry. Fusion of biodynamic heterocyclic systems have proved to be very significant for the design of a new molecular framework of potential drugs with broad range of pharmacological activities. Among fused heterocyclic framework, pyrano-pyrimidines attracted major attention in recent years. Pyrano-pyrimidines are annulated uracils which have received considerable attention over the past years due to their wide range of biological activity. Compounds of these ring systems have diverse pharmacological activities such as anti-tumour, cardiotonic, hepatoprotective, antihypertensive, anti-bronchitic and antifungal activity. Moreover, functionalized 4*H*-pyran derivatives have played increasing roles in synthetic approaches to promising compounds in the field of medicinal, agrochemical, cosmetics, and pigment industries. Currently, many marketed drug molecules having 4*H*-pyran moiety are in use. Thus, we propose one-pot multi-component reactions of arylidene malononitriles generated in situ with thiobarbituric acid using L-Proline as an organo catalyst.

In our continued interest in the development of highly expedient methods for the synthesis of annulated pyrimidines, we report in this paper a novel three-component one-pot synthesis of fully functionalized pyrano-pyrimidines.

Plasmonic Field Engineering in Au–Polymer–Pt Nanoarchitectures for Enhanced Photocatalytic Hydrogen Production

Vasilii Burtsev[a], Jana Rosenkranzova[a], Elena Miliutina[a,b], Václav Švorčík[a], Oleksiy Lyutakov[a]

[a] *Department of Solid State Engineering, University of Chemistry and Technology, Prague, Czech Republic*
[b] *Materials Centre, Faculty of Science, J. E. Purkyně University, Ústí nad Labem, Czech Republic*

Keyword: MIM, HER, Engineering, Hybrid structures, Surface plasmon

The efficient transformation of solar energy into chemical fuels requires rationally designed nanostructures capable of concentrating and manipulating light [1-3]. Here, we present a class of hybrid architectures composed of a plasmonic metal, a dielectric polymer interlayer, and a thin catalytic layer. These structures are engineered to support the formation of gap surface plasmon (GSP) modes under illumination with visible light [2,3]. Numerical simulations demonstrate that optical field localization within the dielectric gap is highly sensitive to its thickness, with a distinct regime where plasmonic coupling between the metallic layers is maximized. In this regime, strong electromagnetic confinement near the catalytic interface promotes efficient enhancement of samples redox activity.

In particular, photoelectrochemical measurements, performed under simulated solar illumination and monochromatic LED excitation, tuned to match the plasmon resonance, demonstrate a pronounced enhancement in water splitting and hydrogen evolution. Observed reaction kinetic enhancement is in good agreement with the electric field distributions estimated from numerical simulations. Incorporating either overly thin or excessively thick dielectric spacers between plasmon-active and redox-active metals exhibits reduced performance, attributed to non-radiative damping in the former case and weakened plasmonic coupling in the latter. These findings highlight the critical role of precise control over geometry and dielectric gap thickness in proposed architectures, and contribute to the fundamental understanding of light–matter interactions relevant to solar-driven hydrogen production.

Acknowledgements

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Session: Nanobiotechnologies

Invited Lectures

Regular Lectures

Poster Presentations

Applications of non-toxic inorganic WS_2 nanotubes: from nanocomposite bioresorbable scaffolds for cardiovascular diseases and tissue engineering to artificial vision system

, A. Zak[1], Lison Rocher[2], Yao Guo [3], T. McNally[4], J. Kornfield [5],*

[1]HIT-Holon Institute of Technology, Israel; [2]Queen's University Belfast, UK, [3]Beijing Institute of Technology, China; [4]University of Warwick, UK, [5]California Institute of Technology, USA
**e-mail: alzak.@hit.ac.il*

Inorganic nanotubes (NTs) composed of layered WS_2 and MoS_2 exhibit unique properties arising from their nanoscale dimensions, closed-cage arrangement of the layers into polar and chiral nanocylinders, as well as from their surface chemistry. Unlike their bulk WS_2 micron-scale counterparts, nanotubes demonstrate piezo-resistivity, photovoltaic effect, high electrocatalytic activity and mechanical strength. Notably, a fully functional artificial vision system has been shown, leveraging the memory effect generated by programmable photoelectric responses and sliding ferroelectricity in multiwalled WS_2 nanotubes [1].

The nanocomposite of WS_2 nanotubes with poly(lactic acid) (PLA) was examined for the fabrication of a bioresorbable vascular scaffold (BVS) to support artery regeneration without permanent mechanical constraint and exhibiting low cytotoxicity in vitro [2]. It was shown that WS_2NTs contribute to the reinforcement of PLA (allowing for a thinner device), increase radiopacity (providing better intraoperative visibility), and reduce friction. They are well dispersed and strongly oriented along the axis of the PLA scaffold tube while extruded, and stay dispersed and aligned after expansion [3]. WS_2 NTs significantly increase the rate of PLA crystallization, and using WS_2NTs modified with silane increases both the elongation at break and the tensile toughness by 600% relative to neat PLA, without impacting the stiffness or strength of the polymer [4].

A new biomaterial for bone tissue engineering has been developed using a nanocomposite made of Poly (propylene fumarate) (PPF) and biocompatible WS_2 nanotubes [5]. Mechanical testing of this composite has shown a significant enhancement in various properties, including compressive modulus, compressive yield strength, flexural modulus, and flexural yield strength, with improvements ranging from 28% to 190% compared to the pure polymer.

The extensive study of these nanomaterials became possible due to the breakthrough in their vapor-gas-solid (VGS) synthesis, resulting in pure phase and macroscopic amounts [6,7].

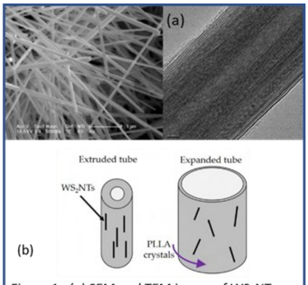

Figure 1. (a) SEM and TEM image of WS_2NT ; (b) PLA-WS_2NT composite tube for BVS.

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Artificial amyloids as implantable depots for the slow delivery of protein nanoparticles and therapeutic proteins

Antonio Villaverde [a,b,c]

[a] *Institut de Biotecnologia i de Biomedicina, Universitat Autònoma de Barcelona, Spain*
[b] *CIBER of Bioengineering, Biomaterials and Nanomedicine, Spain*
[c] *Departament de Genètica i de Microbiologia. Barcelona, Universitat Autònoma de Barcelona, Spain*

Keywords: Recombinant proteins, Sustained release, Nanoparticles, Protein materials, Drug delivery

By leveraging a controlled interaction between divalent cations (mainly the ionic form of Zn, Zn^{+2}) and polypeptides tagged with histidine-rich tags [1], we have developed a straightforward in vitro method to assemble, in a reversible way, protein-only granules at the microscale. These structures exhibit robust mechanical stability due to their amyloid-like organization, which mirrors the architecture of functional, non-toxic amyloids in nature, including secretory granules from the mammalian endocrine system. Designed to incorporate biologically active proteins, these granules functionally resemble those that naturally store and release peptide hormones into the bloodstream. When administered subcutaneously in mice, such mimetic artificial versions prove to be safe and the forming protein biologically accessible [2], acting as dynamic depots that release their protein content slowly over time, primarily in the form of stable, nanosized oligomers. The sustained release, linked to the progressive disintegration of the material by Zn chelation, lasts for several weeks. By engineering the building block proteins with tumor-targeting peptides, the system enables the released nanoparticles to home in on tumor tissues [3], penetrate cancer cells, and carry out specific therapeutic roles, such as delivering cytotoxic agents directly to tumor sites [4]. The ability of the platform to deliver functional nanoparticles for precision medicine has been successfully validated in cancer therapy. Beyond oncology, the application of these materials has been explored in various biomedical areas, including infectious diseases, vaccine delivery and regenerative medicine, demonstrating the versatility and promise of this approach as an emerging drug delivery technology.

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Digital holography to study microbiology and force-actuated bacteria adhesion

Erik Reimhult[a,b], Peter van Oostrum[a,b], Andreas Lundgren[a,c]

[a] *Institute of Colloid and Biointerface Science, BOKU University, Muthgasse 11, A-1190 Vienna, Austria*
[b] *Holloid GmbH, Muthgasse 11, A-1190 Vienna, Austria*
[c] *University of Gothenburg, Medicinaregatan 7B, 41390 Göteborg, Sweden*

E-mail: erik.reimhult@boku.ac.at

Keyword: In-Line Digital Holography, Bacterial Adhesion, 3D Live Imaging, Fimbriae

Microbiology research has leaned heavily on two legs: microscopy and genetics. The latter has evolved rapidly and dominated the conversation over the last decade. Still, many questions, such as concerning physical interactions and organization, can only be answered by microscopy, but the general application of microscopy tools in microbiology has progressed less visibly.

We will show examples of using live microscopy to study bacterial adhesion and growth. In particular, we will present digital holography applied to this purpose. We have developed a low-cost, high-resolution, in-line digital holographic microscopy setup that allows us to monitor microorganism and their interactions on timescales from milliseconds to months in 3D.

As a scientific use case, we will focus on how we used these methods and nanopatterned surfaces to demonstrate an unknown, general, force-mediated adhesion mechanism for bacteria possessing pili or fimbriae. Many bacteria interact with surfaces via long (µm) and thin (nm) tethers called fimbriae or pili. We investigated the role of fimbriae in the interaction of *Escherichia coli* (*E. coli*) under shear with surfaces displaying different densities of nanoscopic mannose or hydrophobic domains. Using in-line digital holography, we mapped 3D trajectories of *E. coli* over these surfaces with ~50 nm precision at ms time resolution, i.e., we determined bacteria position, velocity, size, and orientation. Flow shear forces acting on the bacteria were measured by resolving the laminar shear flow profile from the movement of free-flowing bacteria. This demonstrates the technique as a novel, efficient tool to analyze bacteria's nanoscale interactions with surfaces quantitatively.

We show that fimbriated *E. coli* undergo a rolling motion on surfaces, irrespective of binding specificity, which is controlled by the fimbriae binding strength and the number of fimbriae forming bonds with the surface. The rolling motion slows down and eventually stops in response to increasing the flow rate. The loss of translational motion is caused by a shear force-induced push of the bacteria toward the interface. Pushing the bacteria closer to the surface increases the binding valency, as shorter fimbriae can bind to the surface. In contrast to other force-controlled binding mechanisms, e.g., catch-bonds, force modulation of the binding valency is generic.

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Assessing Cobalt Nanoparticles and Nanocomposites for Biomedical Applications and Water Remediation

Erwan Rauwel[a], Laura Simonelli[b], Carlos Marini[b], Rohit Kumar[c], Glémarie Hermosa[a], Kristi Praakle[a], Isabelle Gélard[d], and Protima Rauwel[e]

[a] *Estonian University of Life Science, Inst. of veterinary medicine and animal science, Tartu, Estonia*
[b]*ALBA synchrotron, CELLS-ALBA Synchrotron Radiation Facility, Spain*
[c]*Estonian University of Life Science, Inst. of forestry and Engineering, Tartu, Estonia*
[d]*Université Grenoble-Alpes, Minatec-LMGP, France*
[e]*Estonian Aviation Academy, Department of Aeronautical Engineering,Tartu, Estonia*
E-mail: erwan.rauwel@emu.ee

The world is presently facing multiple interconnected challenges like water pollution and emerging pathogens, and water resource management is a notorious reality known for decades [1]. Metallic nanoparticles (MNP) and nanocomposites, due to their unique properties, spurred a lot of interest and may be a solution to circumvent these threats [2,3] or at least decrease their impact on the environment and human society. Among the candidate, cobalt MNP and their nanocomposites do not have been extensively studied due to their pyrophoric properties that prevent their easy integration in such applications. The paper describes the application of ultrastable cobalt nanomaterials for the extraction of heavy metal ions present in freshwater and wastewater. Cobalt is a non-cumulative element in human body, and toxicity studies demonstrated their low toxicity against human cells. We developed nanocomposite combining sand, glass, porous glass and polymer support to extract heavy mental ions in a solid coating by a single passage through the filter, and extract contaminants from water with high yield (3360 mg/g for manganese [4] and 6143 mg/g for copper ions). The extracted heavy metal can be reclaimed when the filter is exhausted. The cobalt nanocoating induces the fast growing of a metallic or metal oxide coating on the surface of the nanocomposite that produce original nanostructures studied by XRD, SEM and XAS. The extraction has been studied through batch and dynamic modes using adsorption isotherms. Many water samples were tested (lake water, well water, oily water, ground water). The extraction capability and the adsorption mechanism of the nanocomposite will be discussed in detail. Such nanocomposite can be used on large scale enabling to clean water from rivers to make it safer and in the same time extracting valuable resources to promote circular economy. The nanocomposite also exhibits antimicrobial properties that can kill microorganisms present in water. The antimicrobial properties were study against bacteria (*E. coli*, *Staphylococcus A.*), virus (SARS-Cov-2) and fungi (*Microsporum canis*)[5], and showed a high toxicity against all microorganisms.

In a larger extend, the technology can also be applied to mining activities or translated for producing new nanostructure like nanostructured electrodes with a large specific surface.

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Targeting metastatic CXCR4$^+$ cancers through self-assembled, self-delivered cytotoxic proteins

E. Vázquez [a,b]

a Institut de Biotecnologia i de Biomedicina, Universitat Autònoma de Barcelona, Spain
b Departament de Genètica i Microbiologia Universitat Autònoma de Barcelona, 08193 Cerdanyola del Vallès, Barcelona, Spain
E-mail:esther.vazquez@uab.es

Keyword: Nanostructured toxins, targeted drug delivery, immunotherapy

Proteins are highly adaptable macromolecules that, when properly engineered and tailored, can meet the structural and functional requirements demanded in various biomedical applications. Our research focuses on designing modular protein versions that specifically target and bind the CXCR4 cell surface receptor, thus internalizing in CXCR4-expressing cells. Being this protein overexpressed in metastatic cancer stem cells, this strategy allows a selective and highly precise delivery into such cell types, in various CXCR4$^+$ human cancer types.

If these engineered proteins incorporate histidine-rich peptides, they self-assemble into oligomeric nanoparticles displaying multiple copies of the CXCR4 ligand. In animal models, these multivalent nanoparticles demonstrate optimal biodistribution, enhancing their responsiveness to changes in receptor expression. Furthermore, by incorporating genetically encoded cytotoxic polypeptides, such as proapoptotic proteins, venoms, or toxins, these protein-only materials exhibit intrinsic antitumor activity in absence of side toxicities, based on very high precision the delivery in vivo. Notably, the toxins incorporated into these nanoparticles induce pyroptosis, an inflammatory form of cell death. This process not only eliminates tumor cells but also triggers innate antitumor immunity, contributing to a longer-term effect against tumors. Successful testing in orthotopic models of metastatic and disseminated cancer validates the anti-metastatic potential of these functional materials.

In parallel, our research delves into the architectonic principles underlying the formation of protein-only nanoparticles as efficient drugs. This work, overall, enables precise control over the composition and organization of these nanomaterials, advancing our understanding and manipulation of their unique properties for biomedical applications.

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Multivalent Interactions in the Detection of DNA and Viruses

Jurriaan Huskens

Molecular NanoFabrication group, MESA+ Institute & TechMed Centre, University of Twente, Enschede, The Netherlands
E-mail: j.huskens@utwente.nl

Keywords: Multivalency, Receptor-ligand interactions, Influenza, DNA, Sensing

Multivalency describes many interactions in Nature, for example, the interaction between viruses and cell membranes.[1] The influenza virus binds through multiple sialyl-terminated carbohydrates (SLNs) non-covalently interacting with hemagglutinin coat proteins of the virus particle. This interaction is weakly multivalent in nature, and therefore it responds very sensitively to the density of carbohydrates. This behavior explains the large differences between virus affinities observed for mutations in the receptor binding domain.

A key aspect of the multivalent interaction of viruses at cell membranes is its strong, non-linear dependence on the receptor density displayed at the surface. We here show the use of surface gradients of receptor-modified supported lipid bilayers (SLBs) to visualize and quantify the receptor density dependence in one microscopic image. This technique is called “Multivalent Affinity Profiling”.[2] The fitting of the data by a thermodynamic model allows quantification of the threshold density, comparison of binding selectivities for different virus strains, and thus offers a molecular understanding of the supramolecular binding energy landscape.[3] This supramolecular and nanoscopic picture links fundamental molecular aspects of binding to biological processes of antigenic drift and zoonosis.

The same principles of weak multivalent and superselective binding can be used in the design of a device that selectively captures the cancer biomarker hypermethylated DNA (hmDNA).[4] The selectivity is achieved by careful density control over the surface coverage of the proper receptor for hmDNA, the methyl-binding domain (MBD) protein.[5] Microfluidic devices coated with monolayers of MBD thus allow purification and up-concentration of hmDNA from solution mixtures with large backgrounds of non-methylated DNA, from cell extracts and from patient samples. This technique promises a faster and cheaper method to employ hmDNA as a biomarker in liquid biopsies, with potential applications as a screening method and for follow-up of treatment.

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Role of nano- and microreactors for tumour modeling and clinical diagnostics

Larysa Baraban[1,2]

[1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Radiopharmaceutical Cancer Research, 01328 Dresden, Germany
[2]Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, 01307 Dresden, Germany

We propose the system of nanoliter reactors fabricated using the droplet-based microfluidic approach as a scaffold for 3D multi-spheroid tumour, and as a tool for real time clinical diagnostics[1]. First, 3D tumour model incorporating prostate stem cell antigen (PSCA) modified PC3 human prostate cancer cells and fibroblast activation protein (FAP) modified fibrosarcoma HT1080 cells embedded within soft hydrogel microbeads, to trial the immunotherapy based on the universal chimeric antigen receptor (UniCAR) T cells, and give new insights into the impact of FAP on the immunotherapeutic treatment of solid tumors. First, we demonstrate successful chemoattraction and infiltration of UniCAR T cells into the area of solid tumors, overcoming artificial extracellular matrix barriers. Next, we observe the synergistic efficacy of a dual-targeting CAR T cell approach against both FAP and PSCA antigens, which represent the tumor microenvironment and the tumor, respectively.

On the other hand, we use the system of microfluidic droplets to establish real time and high frequency biomarker detection. The liquid can be divided into nanoliter compartments that contain the reagents for detecting different analytes in the sample, e.g. glucose, lactate or other protein-based species. Next, nanoliter compartments are transported towards detector and read-out one-by-one, enabling time-resolved monitoring of the biomolecular markers. To enable real-time bedside examination of postoperative patients, we developed a portable, droplet-based fluid device. The clinical validation of the device is carried out using two models: the analysis of α-amylase levels in drainage secretions after abdominal surgery[2] (1) and the lactate levels in blood and interstitial fluid in frames of animal studies[3] (2). The presented droplet-based platform can be applied for analysis of different body fluids, diseases, and towards a broader range of biomarkers, including lipase, bilirubin, lactate, inflammation, or liquid biopsy markers, paving the way towards new standards in postoperative patient monitoring.

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Nanodiamond quantum thermometry for biological applications

Masazumi Fujiwara

Department of Chemistry, Okayama University, Okayama, Japan
E-mail: masazumi@okayama-u.ac.jp

Keyword: Nanodiamond, Quantum sensing, Temperature

Temperature is a fundamental parameter in biological processes, yet traditional thermometers fail to capture the spatial heterogeneity of temperature at the nanoscale. FNDs, as quantum thermometers, offer a novel solution, enabling localized temperature measurements in complex environments. Since the first demonstration of diamond quantum thermometry in 2013 [1], its applications have expanded across fields such as microfluidics, joule heating, and biological systems. I will talk about the following two topics.

Biological applications

We have employed FNDs to probe temperature dynamics in Caenorhabditis elegans. We successfully integrated a particle tracking algorithm into FND thermometry and demonstrated real-time temperature measurements in vivo [2,3]. These findings highlight the importance of understanding temperature dynamics at the micro or nanoscale in biological systems. While there remain technical challenges such as quantification of temperature and particle-by-particle inhomogeneity of sensing performance, FND-based thermometry offers a powerful tool for studying these processes and could contribute to advances in fields such as regenerative medicine, neuroscience, and developmental biology. Further, to enhance usability, we developed a notch-shaped coplanar waveguide antenna on glass-chip platforms [4]. This architecture ensures uniform ODMR detection, scalable to various bioassay formats such as multi-well plates and glass-bottom dishes. The large detection area and broadband microwave excitation improve sensitivity and enable compatibility with a wide range of biological samples, including cultured cells and tissues.

Quantum-Grade FNDs

Achieving high sensitivity remains a critical challenge in FND-based quantum sensing. We engineered quantum grade FNDs with reduced spin impurities including N and 12C, while keeping the bright fluorescence [5]. These FNDs exhibited a 5-fold increase in T1 and an 11-fold increase in T2 in NV spin relaxation times, approaching bulk-like spin properties. This breakthrough enables precise temperature measurements with reduced microwave power, minimizing potential biological damage.

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BioHybrid Hydrogel with Oxygen, Drug and Probiotic Metabolite Co-Delivery

Nermin Seda Kehr[a], Ulvi Süleymanzade[a], Yağmur Damla Demir[a], Tuğba Ezgi Şahin[a]

[a] *Department of Chemistry, Faculty of Science, Izmir Institute of Technology, İzmir, Türkiye*
E-mail: sedakehr@iyte.edu.tr

Keyword: Oxygen, anticancer drug, probiotic metabolites, hypoxia, pH-responsive nanomaterials

Cancer is a global health problem affecting countries all over the world. Both traditional and modern methods or combinational strategies do not consider the impact of hypoxia and subsequent chronic inflammation on cancer tissue development and metastasis, despite the fact that hypoxia, cancer and inflammation share an interdependent relationship. Therefore, oxygen (O_2) generating and transporting systems have been developed to ensure adequate and controlled O_2 delivery to tissues.[1] However, there are few studies using O_2 and drug-releasing nanoparticles for cancer therapy under hypoxic conditions.[2,3]

In this context, we have developed a novel injectable living biomaterial called BioHybrid Hydrogel, which consists of O_2 and anticancer drug-carrying nanomaterials and probiotics encapsulated in a 3D hydrogel network. This biomaterial is capable of O_2 release and co-delivery of pH-sensitive anticancer drug and anticancer and anti-inflammatory probiotic metabolite. Moreover, it provides higher healthy cell viability than cancer cells under hypoxic conditions. Therefore, it has the potential to promote improved minimally invasive multidrug therapy applications with cancer cell under hypoxic conditions. To our knowledge, this novel multifunctional biomaterial combines for the first time a stimuli sensitive non-viable drug delivery system with a stimuli sensitive viable drug delivery system for cancer therapy.

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Magnetic Micro- and Nanorobots

Salvador Pané[a]

[a] *Multi-Scale Robotics Lab, ETH Zürich, Tannenstrasse 3, CLA H9, 8092, Zürich, Switzerland*
E-mail: vidalp@ethz.ch

Keyword: Microrobotics, Nanomedicine, Magnetoelectrics

An emerging family of robotic systems are untethered magnetic micro- and nanorobots, tiny vehicles that can move in their swimming environments by means of magnetic fields. One of the ultimate goals of small-scale robotics is to develop machines that can deliver drugs or realize other medical missions in confined spaces of the human body [1]. Other applications include water remediation or “on-the-fly” chemistry [2]. The recent rapid developments in small-scale robotics are undeniably related to advances in material science and manufacturing. However, while many applications have been demonstrated, aspects such as complex locomotion, multifunctionality, biocompatibility and biodegradability need to be further investigated for the successful translation of these devices to real applications. To this end, new material-based concepts and novel fabrication schemes are urgently required.

In this talk, I will introduce two of our latest developments in small-scale robotics. In the first part, we will show how 3D printed microtemplates can be exploited to produce complex robotic microstructures made of rigid metals, soft polymers and combinations of these [3]. As a result, topologically complex metal-organic structures can be realized with micrometric resolution. The second part of this talk will be focused on multiferroic small-scale robots [4]. These small-scale robots consist of multiferroic magneto-electric composite materials, which have the ability to generate an electric field under the application of an external magnetic field. Micro and nanorobots capable of wirelessly delivering electric fields can be used for electrostimulation of cells for the central nervous systems applications, or for bone tissue engineering.

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Self-immolative poly(lipoic acid) brushes on silica nanoparticles as enzyme reservoir

Alexandre Adam[a], Antara Pal[a], Jan Skov Pedersen[a], Brigitte Städler[a]

[a] *Interdisciplinary Nanoscience Center, Aarhus University, 8000 Aarhus, Denmark.*
E-mail: aadam@inano.au.dk

Keyword: Self-immolative polymer, Enzyme carrier, Poly(lipoic acid), Astrocytes

Self-immolative polymers are a class of materials capable of undergoing controlled degradation upon exposure to specific stimuli. Due to their unique and very fast head-to-tail depolymerization behavior, these materials are particularly suitable for applications involving controlled molecular release, biosensing, molecular amplification, and recyclable material development. Polymers based on disulfide backbones are of particular interest due to the intrinsic dynamic nature of the disulfide bond, which enables fast and selective depolymerization via thiol-disulfide exchange, especially relevant in biological and complex environments.

We present the mild synthesis of poly(lipoic acid) (PLA) brushes grafted onto thiolated silica nanoparticles to create a degradable scaffold for enzyme immobilization and triggered release. Comparative analyses of bulk polymerized PLA to surface polymerization of PLA as well as the subsequent depolymerization when exposed to glutathione were performed using NMR-based techniques, electron microscopy, and small angle X-ray scattering (SAXS) measurements. Notably, SAXS measurements using a synchrotron source successfully provided insights into the structural evolution and depolymerization mechanisms of the polymer brushes on the silica colloid surfaces.
We demonstrated that lactate dehydrogenase was efficiently immobilized in the PLA brushes and upon release, the enzymatic activity was preserved. Finally, we biologically evaluated these nanoparticles in astrocytes in terms of short-term toxicity, uptake efficiency as well as intracellular location and activity. Taken together, this colloidal platform holds promises for efficient intracellular enzyme delivery to mammalian cells.

Green carbon dots derived from knotweed with high efficacy of free-radical scavenging and wound-healing properties

Jun Wang[1], Xiangyu Zhou[1], Jian Yang[1], Bo Sun[1], Wanyi Fang[1,2]

Department of Biomedicine, Hubei University of Technology, China 430068
Department of physiology, University of Alberta, Canada T6G 2R3
E-mail: jun_wang@hbut.edu.cn

Carbon dots (CDs) derived from natural plants usually have photo-stable, highly biocompatible and cost-friendly properties, which have numerous application potentials for nanobiotechnologies. Synthetic green CDs for wound healing are rare, with very few examples from herbs. In this study, we presented one type of wound-healing CD from knotweed (KT-CD) root through deep eutectic solvent extraction for the first time.

The obtained KT-CD exhibited excellent free-radical scavenging activity for DPPH• and ABTS•+. Cytotoxicity and embryotoxicity results indicated that they had lower toxicity and better biocompatibility than that of CDs derived from organic solvents. In addition, KT-CDs effectively scavenged reactive oxygen species (ROS) in A549 cells, 293T cells, and zebrafish, with an excellent wound healing effect on mouse skin. Further characterization of this CD showed that it had high contents of hydroxyl groups in its nanoparticles.

In short, we successfully synthesized one KT-CD that scavenges free radicals efficiently and helps wound healing due to its high antioxidant property.

Crossing Artificial Cell Membranes with Nanomotors

Miguel A. Ramos Docampo[a], Brigitte Städler[a]

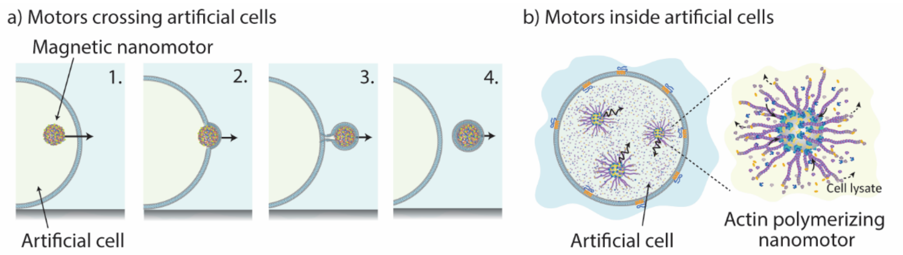
[a] *Interdisciplinary Nanoscience Center (iNANO), Aarhus University, Gustav Wieds Vej 14, 8000 Aarhus, Denmark*
E-mail: miramos@inano.au.dk

Keywords: Nanomotors, Artificial cells, Membrane crossing

Nanomotors are a subgroup of active colloids that can self-propel outperforming Brownian (random) motion by converting an input energy into kinetic energy.[1] When it comes to the interaction of nanomotors (or nanoparticles) with mammalian cells, phagocytosis is still predominant. However, harnessing the power of nanomotors can help to cross cellular membranes to either enter the cell cytosol or escape from the endo/lysosomes, which are key challenges for nanoformulations in biomedical therapies.

Here, we explore the potential of nanomotors to cross the membranes of artificial cells (**Scheme 1**). First, we employ magnetically actuated motors with the aim of identifying parameters that enables the motors to enter the lumen of the artificial cells. Different factors are considered, including the motor's size and surface charge, the lipid membrane composition, the density of the medium, and the magnetic field strength.[2] Second, we design a bio-inspired nanomotor that can recruit actin monomers and polymerize them into fibers, aided by other assisting proteins found inside the cytosol of mammalian cells. During this process, the motors self-propel via a Brownian ratchet mechanism of propulsion, like that used by certain bacteria like *Listeria monocytogenes*.

Taken together, we identify fundamental design criteria for motors that exhibit sufficient power to cross an important biological barrier i.e., lipid bilayers.



Scheme 1. a) A magnetic nanomotor crossing through the membrane of an artificial cell. b) A polymerization-powered nanomotor moving inside an artificial cell.

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Plant Mediated Graphitic Carbon Nitride for a Sustainable Approach for Future Applications

Priyanka Panchal*[a], Protima Rauwel[b], Glemarie Hermosa[a], Erwan Rauwel[a]

[a] *Institute of Veterinary Medicine and Animal Sciences, Estonian University of Life Sciences Tartu, Estonia*
[b] *Department of Aeronautical Engineering, Estonian Aviation Academy, 61707 Tartu, Estonia*

E-mail: priyanka.panchal@emu.ee*

Keyword : Biomaterial, Graphitic Carbon Nitirde, Enironmental Applications

Researchers from various fields have recently found that using plants, fruits, yeast, algae, fungi, and other green methods to produce nanomaterials are both cost-effective and highly demanding. Compared to conventional synthesis techniques, the plant-based synthesis is seen as an environmentally friendly, affordable, manageable, and stable way to create bionanomaterials.

Among the different nanoscale materials, Graphitic Carbon Nitride (GCN) is recognized as a new multifunctional metal-free n-type semiconductor. It exhibits polymeric structure and can be applied in both biomedical and environmental applications. Therefore, there is a significant need to explore green methods for synthesizing GCN. Although GCN has not be synthesized using biomaterials, current research suggests that, similarly, to metal and metal oxide nanoparticles, the synthesis of GCN through Plant source, could be highly promising for future applications.

In this work, we synthesized plant based GCN and their nanohybrids. GCN was developed using two distinct plant-derived precursors-*Ocimum tenuiflorum* and orange peel without incorporating any external precursors or catalysts. The phytochemical makeup of each plant was pivotal in determining the type of nanomaterial generated. *Ocimum tenuiflorum*, abundant in nitrogenous compounds like alkaloids, flavonoids, and eugenol, promoted the creation of GCN through thermal condensation, where the presence of nitrogen atoms facilitated the development of a polymeric configuration of triazine, heptazine units. On the other hand, orange peel, largely composed of carbohydrates and organic acids, served as a carbon-rich and nitrogen-lacking material, which upon pyrolysis, resulted in the formation of graphene by graphitizing sp^2-hybridized carbon atoms.

Moreover, we evaluated the photocatalytic properties against dyes, their antimicrobial properties and cytotoxicity, and they exhibited significant potential. It highlights that the inherent biochemical composition of each plant source significantly impacts the structural and chemical characteristics of the resulting carbon nanomaterial, which will be discussed in this paper.

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Inducing local lipid changes in *C. elegans* using nanodiamond-based quantum thermometry controlled temperature modulation

Sara Mandic[a], Fumiya Kamada[a], Masazumi Fujiwara[a,*]

[a] *Department of Chemistry, Graduate School of Life, Environmental, Natural Science and Technology, Okayama University, Okayama 700-8530, Japan*
E-mail: masazumi@okayama-u.ac.jp

Keyword: Nanodiamonds, Thermometry, *C. elegans*, Lipids

Caenorhabditis elegans is a free-living nematode species that has been used as a model organism since mid-20th century. One of the reasons for this is the nematode's well-studied genome, combined with large brood size and rapid life-cycle[1]. Additionally, it is known that the culture temperature affects the lipid profile of the nematodes[2]. However, this influence is generally studied in the context of global temperature conditions and their manipulation. Concurrently, nanodiamonds containing nitrogen vacancy centers have been increasingly researched for their capability for measuring temperature, also in biological systems. Due to their small size, and precision of measurements, they can be used for measuring laser-induced temperature changes in *C. elegans*[3]. Furthermore, their high photostability and low biological toxicity after surface functionalization makes them compatible with extended measurement periods, without compromising the target lipid profile.

We have developed a method for precise heating and measurements of the nematodes using fluorescent ND-fed *C. elegans*. By doing so, we could alter the temperature inside specific parts of the nematode bodies. The optimized protocol allowed for post-heating retrieval of the nematodes for lipid staining using Oil red O. Using an NIR laser at 5% power, for 3 minutes, in the area scanning mode, the temperature in the target region was increased by 10 °C. This resulted in a comparable range to the 15°C - 25°C range generally used in demonstrating lipid amount differences in *C. elegans*, allowing for the corroboration of the local heating effects with those of the global heating manipulation. Using this methodology, more precise investigations into *C. elegans* physiology are made possible.

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Graphene-Enhanced Joint Prosthesis for Arthroplasty: A Novel Production Approach

Thyago Pacheco[a], Ahmed Subrati[b], Ítalo Azevedoa Giordano Paterno[a], Ariane Pandolfo[a], Marcio Poças[a], Sergio Moya[b], Sonia Bao[a], João Paulo Longo[a]

[a] *University of Brasilia, Brasília, Federal District, Brazil*
[b]*CICbiomaGUNE, San Sebastián, Guipúzcoa, Spain*
E-mail: thyagojap@gmail.com

Keyword: Graphene, Materials, Nanocomposite, Prosthesis

Ultra-high-molecular-weight polyethylene (UHMWPE) is widely used in joint prostheses due to its biocompatibility and mechanical properties. However, its susceptibility to abrasion and wear can lead to prosthesis failure, the release of polymer fragments, and subsequent immune responses, including aseptic necrosis. To enhance the mechanical and antimicrobial properties of UHMWPE, we incorporated graphene oxide (GO) using a novel solvent-free thermopressing method. This innovative approach, for which a patent has been filed (BR10202400456), aims to improve the durability and performance of arthroplasty prostheses. Two prosthesis types were produced: conventional UHMWPE and UHMWPE-GO. Comparative characterization was performed using Raman spectroscopy, XPS, SEM, and TGA. The thermal analysis revealed that the UHMWPE-GO prosthesis exhibited greater thermal stability than its unmodified counterpart. Mechanical tests demonstrated that the graphene-modified prosthesis required significantly higher force to fracture, indicating improved structural integrity. Additionally, microbiological assays confirmed the antimicrobial activity of UHMWPE-GO, which may help prevent infections and prosthesis-related complications. Furthermore, *in vitro* studies showed enhanced fibroblast adhesion, suggesting good biocompatibility. These findings indicate that the incorporation of graphene oxide into UHMWPE improves the mechanical, thermal, and antimicrobial properties of joint prostheses, potentially extending their lifespan and reducing the need for replacement surgeries. Future studies will focus on regulatory compliance and industrial-scale production to enable clinical application

Gold Nanoparticles and Immobilized Laccase: A Synergistic Approach for Green Catalysis

Ahmed Balah Tahiri[b], Raúl Martínez-Baquero[a], Felipe Hornos[a], Francisco Montilla[b], C. Reyes Mateo[a], Rocío Esquembre[a] & María José Martínez-Tomé[a].

[A] *IDiBE, Miguel Hernández University (UMH). Elche, Alicante, Spain*
[b]*Department of Chemistry-Physics and IUMA, University of Alicante (UA). Alicante, Spain*

E-mail: abalah@umh.es

Keyword: Gold nanoparticles (AuNP), sol-gel, laccase, photothermal, immobilization

Ensuring water quality is crucial for both public health and the stability of ecosystems. Among the many pollutants found in wastewater, phenolic compounds—originating from dyes, pharmaceuticals, and plastic manufacturing—stand out due to their toxicity and persistence. These substances are often resistant to natural degradation, making them particularly problematic. Enzymatic treatment, especially using laccase, offers a promising alternative thanks to its ability to oxidize a wide range of phenolic and aromatic compounds. However, large-scale applications remain limited due to the enzyme's poor reusability and the need for elevated temperatures to maintain its catalytic activity.

This study explores the development of hybrid inorganic materials with simultaneous photothermal and catalytic functionalities. Silica-based matrices were obtained via the sol-gel process and functionalized with gold nanoparticles (AuNPs) to provide photothermal responsiveness. AuNPs were synthesized in solution using the Turkevich method and stabilized with PVP (polyvinylpyrrolidone), then successfully incorporated into the silica matrix during the condensation process. Laccase was co-immobilized within these AuNP-functionalized silica matrices, creating a hybrid system where both the enzyme and nanoparticles coexist in a stable network. The plasmonic behavior of the immobilized AuNPs was evaluated through their absorbance properties and ability to increase temperature under laser irradiation. Laccase was used as a model enzyme and studied in solution for its conformational stability, thermal resistance, and catalytic activity. After immobilization, the enzyme retained its structure, with a slight decrease in thermal stability as shown by fluorescence spectroscopy. When irradiating the gold nanoparticles, a localized increase in temperature was achieved due to their plasmonic properties, which in turn enhanced the catalytic efficiency of the enzyme. These results support the potential of sol-gel matrices as platforms for thermally modulated enzymatic reactions.

Acknowledgments

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Development of core-shell nanocrystals for radiotherapy

David E. Salazar Marcano [a], Elizaveta Maksimova [a], Jonathan De Roo [a],

[a] *Universität Basel, Departement Chemie, Gebäude 1096, Mattenstrasse 22, CH-4058 Basel*
E-mail: david.salazarmarcano@unibas.ch

Keyword: Nanoparticles, Core-shells, Radiotherapy, X-rays

Around half of all cancer patients receive radiotherapy.[1] However, exposure to X-ray radiation to eradicate tumors can also cause damage to healthy tissue. Therefore, in order to reduce the X-ray dose needed and to localize the effect of radiation, nanoparticles have been increasingly explored as radiosensitizers.[2] One common mechanism of action for the anticancer-activity of radiosensitizer nanoparticles involves the production of Reactive Oxygen Species (ROS) upon X-ray irradiation. ROS produced by radiosensitizer nanoparticles can cause damage to biomolecules in cells, such as DNA, resulting in apoptotic cell death. One of the most promising radiosensitizer nanoparticles that have made it through clinical trials are HfO2 nanoparticles.[3] This is due to the high X-ray absorption of HfO2, as a result of the high atomic number of Hf, and the low toxicity of HfO2 when not irradiated. However, the photocatalytic activity at the surface of the nanoparticles could be improved by using a more photoactive material, resulting in enhanced ROS generation. Therefore, with the aim of producing better radiosensitizers for radiotherapy, we are developing core-shell nanocrystals that combine a core with a high X-ray absorption with a more photocatalytically active shell. Furthermore, the current state of the art involves the administration of HfO2 nanoparticles through direct injection into tumors, limiting their delivery to relatively easily accessible tumors. Hence, to expand the scope of these radiosensitizers to additional types of tumors, the functionalization of these nanoparticles with cancer-targeting biomolecules is also being explored.

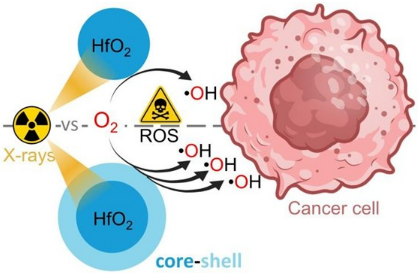

Figure 1 *ROS generation of HfO2 alone vs core-shell nanoparticles upon X-ray irradiation.*

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Electrochemical Bioplatform Based on a Gold Nanoparticles/Graphene Oxide/MoO_3-MoS_2 Nanocomposite and Hydroquinone/Gold Nanotags for the Competitive Detection of Cyfra 21-1

Patrawadee Yaiwong[a], Siriporn Anuthum[a], Panwad Chavalekvirat[b,c], Pawin Iamprasertkun[b,c],
Jaroon Jakmunee[a], Kontad Ounnunkad[a*]

[a]Department of Chemistry, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand
[b]School of Bio-Chemical Engineering and Technology, Sirindhorn International Institute of Technology, Thammasat University, Pathum Thani 12120, Thailand
[c]Research Unit in Sustainable Electrochemical Intelligent, Thammasat University, Pathum Thani 12120, Thailand
E-mails: kontad.ounnunkad@cmu.ac.th, suriyacmu@yahoo.com

Keywords: Electrochemical competitive detection, gold nanoparticles, graphene oxide, MoO3-MoS2, hydroquinone, CYFRA 21-1, lung cancer, biomarker

Lung cancer is one of the deadliest forms of cancer, with a significantly high mortality rate. Consequently, early diagnosis is essential for effective treatment and better survival chances. The cytokeratin 19 fragment, CYFRA 21-1, is one of the most crucial protein biomarkers for detecting lung cancer, strongly associated with non-small cell lung cancer, especially squamous cell carcinoma. Furthermore, the CYFRA 21-1 level in normal human serum is generally lower than 3.3 ng mL^{-1}. Hence, developing a new method for the early detection of CYFRA 21-1 is essential. In this work, we propose a new highly sensitive competitive electrochemical immunosensor for detecting CYFRA 21-1 using gold nanoparticles (AuNPs)/graphene oxide (GO)/MoO_3-MoS_2 nanocomposite and gold nanotags. The newly developed triple nanocomposite of AuNPs/GO/MoO_3-MoS_2 is employed to modify a screen-printed electrode (SPE). This nanocomposite provides a large specific surface area, swift electron transfer, outstanding electrical conductivity, and excellent biocompatibility for antigen immobilization. Subsequently, the CYFRA 21-1 antigen is immobilized onto the modified electrode, creating the CYFRA 21-1/AuNPs/GO/MoO_3-MoS_2/SPE. In parallel, AuNPs are conjugated with an anti-CYFRA 21-1 antibody and a hydroquinone (HQ) probe molecule, resulting in nanotags (HQ/anti-CYFRA 21-1/AuNPs). In the presence of the target, immunocomplexes are formed through antigen-antibody interactions in the nanotag solution. After the introduction of the unbound HQ/anti-CYFRA 21-1/AuNPs nanotags in the resultant solution onto CYFRA 21-1/AuNPs/GO/MoO_3-MoS_2-modified SPE, the formation of immunocomplexes occurs, enabling the sensitive detection of the CYFRA 21-1 antigen through recording the HQ current response. The immunosensor achieves sensitive detection of CYFRA 21-1, with a linear range from 0.010 to 10 ng mL^{-1} and a limit of detection of 0.010 ng mL^{-1}. Moreover, the sensor exhibits high selectivity, reliable reproducibility, and exceptional stability. Simultaneously, the proposed competitive immunosensor can effectively detect CYFRA 21-1 in human serum samples, demonstrating good recovery. Importantly, the developed immunosensor offers several advantages, including simplicity, cost-effectiveness, and high reproducibility. Additionally, it holds significant potential for the early detection and screening of CYFRA 21-1 in lung cancer.

Light-activated antibacterial performance of a novel MoAlB@MBene core-shell nanostructure

Michał Jakubczak[a], Dominika Bury[a], Verónica Montes-García[b], Artur Ciesielski[b,c], Michael Naguib[d,e], Agnieszka Maria Jastrzębska[a]

[a]*Faculty of Mechatronics, Warsaw University of Technology, św. Andrzeja Boboli 8, 02-525 Warsaw, Poland*
[b]*Institut de Science et d'Ingénierie Supramoléculaires (I.S.I.S.), Université de Strasbourg&CNRS 8 allée Gaspard Monge, Strasbourg 67000, France*
[c]*Center for Advanced Technologies, Adam Mickiewicz University, Uniwersytetu Poznańskiego 10, 61-614 Poznań, Poland*
[d]*Department of Physics and Engineering Physics, Tulane University, New Orleans, LA 70118, USA*
[e]*Department of Chemistry, Tulane University, New Orleans, LA 70118, USA*
E-mail: michal.jakubczak.dokt@pw.edu.pl

Keyword: 2D nanomaterials, MBene, antibacterial properties, bioactivity, material-cell interactions

The growing threat of antibiotic-resistant bacteria underscores the urgent need for alternative antimicrobial strategies that bypass conventional drugs [1]. Two-dimensional (2D) nanomaterials have emerged as promising candidates due to their tunable physicochemical properties and strong bio-nano interactivity. Among them, MBenes—transition metal borides derived from MAB phases—represent a novel class with high biomedical potential. Structurally similar to MXenes but incorporating biologically active boron, MBenes offer unique advantages in electronic structure, surface chemistry, and light-responsiveness [2]. Recent studies suggest that MBenes can act as efficient light-activated biocidal agents, especially when engineered into core-shell architectures. Their variable crystal symmetries and layered configurations may enhance reactive oxygen species (ROS) generation and bacterial stress, even in darkness. These traits position MoAlB-derived MBenes as strong candidates for antimicrobial coatings and wound care [3].

We synthesized a novel 2D MoAlB@MBene core-shell structure *via* mild wet-chemical etching and evaluated its antibacterial activity against *Escherichia coli*, *Staphylococcus aureus* and *Bacillus subtilis*. The material exhibited strong bactericidal effects, inducing intracellular ROS and singlet oxygen ($^1O_2$), with clear signs of bacterial stress including morphological changes and biofilm formation.

Spectroscopy revealed broad visible light absorption and a unique UV absorption edge, corresponding to direct (1.67 eV) and indirect (0.74 eV) band gaps. These features supported efficient light harvesting. Upon white light exposure, antibacterial efficiency significantly increased, reducing bacterial viability to ~20% across all strains. The response was concentration- and time-dependent.

The core-shell structure enhanced the material's dispersibility, stability, and surface reactivity, promoting better interaction with bacterial membranes and light absorption. These findings provide insight into light-activated antimicrobial mechanisms of 2D materials and support the biomedical promise of MBenes. MoAlB@MBene represents a multifunctional platform merging intrinsic bioactivity with external photoactivation. Its broad-spectrum antibacterial efficacy, light-responsiveness, and favorable chemistry make it a strong candidate for next-generation wound dressings, antimicrobial coatings, and infection-resistant medical devices.

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Nanostructured Fluorescent Eutectogels: A Versatile Platform for Bioanalytical Applications

Raúl Martínez-Baquero[a,b], Yolanda Alacid[a,b], Rocío Esquembre[a], Francisco Montilla[b], María José Martínez-Tomé[a*] and C. Reyes Mateo[a*]

[a] *IDiBE, Miguel Hernández University, Elche, Alicante, Spain*
[b] *Department of Physical Chemistry and University Institute of Materials of Alicante (IUMA), Alicante, Spain*
E-mail: raul.martinezb@umh.es

Keyword:, Deep eutectic solvents (DES), Fluorescent nanocomposites, Enzyme immobilization, Eutectozyme, Biosensing

Recent advances in materials science have driven the emergence of innovative gel-based platforms, among which eutectogels have garnered considerable attention. These materials integrate deep eutectic solvents (DES) into polymeric networks, exploiting their distinctive physicochemical properties—such as low volatility, biocompatibility, and tunable polarity—to surpass the limitations of conventional hydrogel systems.

In this study, we present the development and comprehensive characterization of a novel class of fluorescent nanocomposite eutectogels, engineered through the incorporation of conjugated polymer nanoparticles (CPNs) with distinct emission profiles. These CPNs, synthesized from either polyfluorene or poly(phenylenevinylene) derivatives, provide the system with enhanced optical functionality.

Prior to eutectogel fabrication, the optical stability and emission characteristics of the CPNs were confirmed to remain unaltered in both aqueous and DES environments, ensuring compatibility with the gel matrix. The resulting nanocomposite eutectogels demonstrated high structural integrity, excellent thermal stability, uniform nanoparticle distribution, and long-term preservation of luminescent properties for several weeks under ambient conditions.

To explore their potential in biosensing applications, the fluorescent eutectogels were employed as enzyme immobilization platforms. Alkaline phosphatase was successfully entrapped within the matrix and retained its catalytic activity, enabling the detection of hydrolase activity through fluorescence-based assays. This work represents one of the first demonstrations of enzyme functionality within a eutectogel, underscoring the promising potential of these materials in the development of next-generation biosensors.

A 2,1,3-Benzothiadiazole-Based Fluorescent Macrocycle for Detecting Lysosomal Microenvironment Dynamics

Shahad AlOtaiby[a,b], Aliyah Fakim[a], Niveen M. Khashab[a]

[a] *Smart Hybrid Materials Lab (SHMs), King Abdullah University of Science and Technology, Thuwal, Saudi Arabia.*
[b]*Research Center, King Fahad Medical City, Riyadh, Saudi Arabia.*
E-mail: shahad.alotaiby@kaust.edu.sa

Keywords: Smart nanomaterial, Supramolecular interactions, Lysosomal microenvironment, Polarity and viscosity sensing

Lysosomes play a central role in maintaining cellular homeostasis, and fluctuations in their microenvironment, such as viscosity and polarity, are closely associated with pathological conditions, including cancer and neurodegenerative diseases. This study reports the design and synthesis of a novel [3+3] macrocyclic fluorescent probe incorporating the amphiphilic 2,1,3-benzothiadiazole (BTD) moiety. This macrocycle shows excellent biocompatibility with specific localization in the lysosomes and outperforms commercially available stains in fast staining and long-term live cell imaging. The nanomaterial exhibits distinct real-time fluorescence responses to variations in local viscosity and polarity, and has been demonstrated to be responsive to different levels of lysosomal stress, where the fluorescence increased accordingly. Its unique photophysical behavior enables precise mapping of microenvironmental changes within live cells. The dual sensitivity to viscosity and polarity fluctuations provides a powerful platform for probing lysosomal stress and dysfunction, making this macrocycle a promising candidate for gaining deeper insight into cellular dynamics, improved diagnostics, and early disease intervention. Overall, this BTD-containing macrocycle offers a valuable tool for spatiotemporal imaging and monitoring of lysosomal health, paving the way for advanced diagnostic applications.

Apoptosis Biosensor: Evaluating Drug Impact On Pregnancy

Sara Fernandes[a,b], Catarina L. Nogueira[a], Diana Pinho[b,c], Carla M. Carvalho[a], **Andrea Cruz**[a]

[a] *INL-International Iberian Nanotechnology Laboratory, Avenida Mestre José Veiga s/n, 4715-330 Braga, Portugal*
[b] *CMEMS – Center for Microelectromechanical Systems, University of Minho, 4800-058, Guimarães, Portugal;*
[c] *LABBELS – Associate Laboratory, University of Minho, 4710-057 Braga, Portugal*
E-mail: andrea.cruz@inl.int

Keyword: Apoptosis, Biomarkers, Biosensor, Caspase-3, Pregnancy

In Europe, most neonatal and infant deaths occur in preterm infants, and globally, approximately 450 newborns die every hour. Many pregnant women require medication to manage chronic conditions or pregnancy-related complications. However, pregnancy significantly alters drug pharmacokinetics, making it challenging to predict drug safety and efficacy. Due to ethical concerns, clinical trials in pregnant women are limited, creating a critical gap in research on the effects of medications during pregnancy. To address this issue, it is essential to develop non-invasive methods for assessing maternal and foetal health. By tracking specific biomarkers, researchers can evaluate the safety profile of drugs administered during pregnancy and detect early warning signs of adverse outcomes, including drug-induced toxicity or pregnancy complications such as preeclampsia and intrauterine growth restriction.

Caspases, a family of cysteine proteases, are key regulators of apoptosis [1]. These enzymes can be divided into three main groups: initiator caspases, like caspase-8, which trigger the apoptotic pathway, effector or executioner caspases, like caspase-3, which execute cell death by dismantling the cell's components and inflammatory caspases, like caspase-1. Specifically, caspase-3 plays a central role in executing apoptosis, making it a critical biomarker for detecting abnormal cell death in placental tissues by both extrinsic and intrinsic pathways [2-5].

This work aims to develop and optimise two methods for the detection and quantification of apoptotic biomarkers, specifically caspase-3, providing a safer tool for assessing apoptosis levels during pregnancy. The first method is a direct ELISA, employing an antibody conjugated with a fluorescent dye, thus enabling the establishment of a fluorescence-based technique for the quantitative analysis of caspase -3. The second method is based on electrochemical measurements using magnetic nanoparticles, which serve to pre-concentrate the target biomarker, thereby enhancing the sensor performance. Both methodologies were developed and optimised to allow the detection of low concentrations of caspase-3 within a short timeframe.

Furthermore, various body fluids, including human serum, amniotic fluid, and also cell-culture medium, were employed throughout the validation process to ensure applicability of the methods in different biological contexts. These two complementary approaches provide a reliable strategy for quantifying a key biomarker associated with apoptosis, facilitating a more accurate assessment of apoptotic processes that may be influenced by drugs or pathological conditions, thereby ensuring the safety of the pregnant woman and the foetus.

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Electrochemical Biosensors for the Detection of CCL3 and TGF-β1 as Biomarkers in Inflammatory Disease Screening

Luis Gonçalves[a, b], Diana Pinho[c], **Andrea Cruz**[a]

[a] *INL-International Iberian Nanotechnology Laboratory, Avenida Mestre José Veiga s/n, 4715-330 Braga, Portugal*
[b] *CMEMS – Center for Microelectromechanical Systems, University of Minho, 4800-058, Guimarães, Portugal;*
[c] *LABBELS – Associate Laboratory, University of Minho, 4710-057 Braga, Portugal*
E-mail: andrea.cruz@inl.int

Keyword: Biosensor, CCL3, Inflammation, TGF-β1.

Inflammation plays a vital role in the human body in response to various potentially harmful stimuli, such as pathogens, cell injuries, or toxic compounds [1]. While essential for tissue repair and defence, chronic or dysregulated inflammation can contribute to the development of numerous pathological conditions such as degenerative diseases, fibrosis, cancer, infections, and even ageing [1-2].

Transforming Growth Factor beta 1 (TGF-β1) is a context-dependent cytokine with anti-inflammatory properties, essential for immune homeostasis and, during pregnancy, for maternal-fetal tolerance, placental development, and immune regulation [3-5]. Its dysregulation is linked to several conditions, including cancer [1], pregnancy complications [5], renal disorders [6], and autoimmune diseases [7]. In contrast, chemokine (C-C motif) Ligand 3 (CCL3) is a pro-inflammatory chemokine involved in immune regulation [8], with elevated levels associated with inflammatory and autoimmune diseases, pregnancy complications [9], and certain cancers [8]. Given their clinical relevance, the development of rapid, sensitive, and user-friendly methods to detect biomarkers such as TGF-β1 and CCL3 at the point of care is crucial for improving the diagnosis and monitoring of inflammation-related pathologies and enabling more precise evaluation of disease progression.

This work presents two immunosensors based on Electrochemical Impedance Spectroscopy (EIS), specifically designed and developed for the detection and quantification of TGF-β1 and CCL3. These sensors enable rapid, simple, and highly sensitive analysis across a variety of clinically relevant sample types, including urine, amniotic fluid, blood serum, and cell culture media.

The biosensors provide a label-free platform for real-time monitoring of inflammatory biomarkers, allowing precise evaluation of molecular signatures associated with immune and inflammatory responses. Owing to their sensitivity and versatility, they hold strong potential for diverse clinical applications, including early diagnosis, prognostic assessment, and therapeutic monitoring, in conditions such as autoimmune diseases, infections, cardiovascular disorders, and pregnancy-related complications.

Acknowledgment. This work was funded by European Union´s Horizon 2020 Research and Innovation Programme - Project Lifesaver (ref: LIFESAVER -H2020-LC-GD-2020-3) Under Grant Agreement Number:101036702. https://lifesaverproject.eu//

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Biosensing Approach for Biomarker Detection in Infectious Diseases

Renato Ribeiro[a,b], Catarina L. Nogueira[a], Ana Frangolho[a], Diana Pinho[b,c], Andrea Cruz[a], Carla M. Carvalho[a]

[a] *INL-International Iberian Nanotechnology Laboratory, Avenida Mestre José Veiga s/n, 4715-330 Braga, Portugal*
[b] *CMEMS – Center for Microelectromechanical Systems, University of Minho, 4800-058, Guimarães, Portugal;*
[c] *LABBELS – Associate Laboratory, University of Minho, 4710-057 Braga, Portugal*
E-mail: carla.carvalho@inl.int

Keyword: Infections, Diagnostics, Biomarkers, Magnetic nanoparticles, Optical, Microfluidics

Accurate and timely diagnosis of infectious diseases remains a critical challenge in clinical practice. Biomarkers have emerged as valuable tools for improving diagnosis, enabling early detection, monitoring disease progression, and guiding appropriate treatment decisions. Alongside direct pathogen identification, the simultaneous detection of host-response biomarkers provides valuable insights into infection severity and aetiology. Several biomarkers that are upregulated during the infection process have proven useful in predicting clinical outcomes and in distinguishing between bacterial and viral infections [1]. Among them, interleukin-6 (IL-6) plays a key role in the inflammatory response and has been widely recognised as a clinically relevant biomarker for infection diagnosis, risk stratification, and disease monitoring [2].

In this work, we present a novel biosensing system capable of detecting and quantifying infection-related biomarkers, with a particular focus on IL-6. Due to the typically low concentration of IL-6 in clinical samples, magnetic nanoparticles were employed to selectively separate and concentrate the biomarker from complex biological samples. The magnetically captured IL-6 was then detected and quantified using a fluorescence-based approach by measuring the signal generated from an anti-IL-6 antibody labelled with a high-intensity fluorescent dye. The assay demonstrated high sensitivity and specificity, highlighting its potential to replace conventional ELISA as a faster and more efficient alternative. This approach is being integrated into an optofluidic system previously shown to efficiently concentrate bacterial pathogens from blood [3], to enable automated and multiplexed detection of both pathogens and host-response biomarkers. Together, this approach holds strong promise as an advanced diagnostic tool for infectious disease management.

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2D SBUs and open metal sites in MOF-based photo/electrocatalysis

Dominik Eder,[a] Huang Zheao,[a] Pablo Ayala[a] and Shaghayegh Naghdi[a]
[a]*Institute of Materials Chemistry, TU WIen, Getreidemarkt 9, 1060 Wien, Austria*
e-mail: dominik.eder@tuwien.ac.at

Keywords: *Selective Ligand Removal, Open Metal Sites, 2D SBUs, Photocatalysis, Electrocatalysis*

Metal-Organic frameworks (MOFs) have recently gained interest as an innovative class of photocatalytic and electrocatalytic materials owing to catalytically active oxo-metal clusters connected to photoactive organic linkers through a well-ordered micropore network that yields exceptionally high surface areas. In dynamic processes and especially in liquid phase catalysis, the accessibility of active sites becomes a critical parameter as the reactant diffusion is often limited by the inherently small micropores of MOFs.

In this talk, we will present a promising strategy to overcome this challenge. It involves the synthesis of mixed-ligand MOFs, followed by **selective ligand removal (SELIRE)** upon thermal stimulus to design **microporous-mesoporous MOFs** [1]. As an example, we synthesized photoactive MOFs of the MIL-125 -Ti family with two distinct hierarchical pore architectures resembling either large cavities or branching fractures, both of which significantly improved the photocatalytic hydrogen evolution (HER) rates of the MOFs by up to 500%. In another example, we show that these pores also greatly enhanced the potential of these MOFs to adsorb large molecules, such as glyphosate, from waste water [2]. The enhancements induced by the SELIRE process originate from 1) the formation of new under-coordinated adsorption sites and 2) better access to catalytic sites by facilitating reactant diffusion through the pores.

We will further demonstrate how this mixed-ligand approach can greatly enhance the structural integrity and durability of **zeolitic imidazolate frameworks (ZIFs)** in water-based environments und applied irradiation and electric fields as well as their conductivity and activity towards (photo)electrocatalytic HER and OER reactions [3,4]. Moreover, we will discuss how the creation of **open-metal sites** through the SELIRE process affects the rate limiting steps for these reactions [5]. In the last part, we will briefly explore the benefits of photoactive MOFs with **2D-arranged Ti-SBUs** (i.e. COK-47 as an example) on facilitating charge separation, transport and extraction to adsorbed reactants [6].

References:

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ORGANIZING BODY

European Nanoscience and Nanotechnology Association (ENNA)

Address: Str. Coral, Bl. 3, Entr. D, Apt. 105, Sofia 1000, Bulgaria

The European Nanoscience and Nanotechnology Association (ENNA) is a leading organisation for professionals working across physics, chemistry, and materials sciences.

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We warmly invite you to become part of our community and help shape the future of nanoscience.

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Thank you for being part of NANOMAT2025!

The European Nanoscience and Nanotechnology Association (ENNA) warmly thanks all participants, speakers, authors, and partners who contributed to the success of the International Conference on Functional Nanomaterials and Nanodevices – NANOMAT2025, held in Zagreb, Croatia.

This abstract book brings together innovative research and scientific progress across the fields of nanoscience, nanotechnology, energy materials, catalysis, biomedical nanodevices, and more. It reflects the collaborative spirit and scientific excellence shared by our global community.

We hope this edition has inspired new ideas, valuable discussions, and future collaborations!

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