# TWENTY-THIRD YOUNG RESEARCHERS' CONFERENCE
# MATERIALS SCIENCE AND ENGINEERING

**December 3 – 5, 2025, Belgrade, Serbia**

# Program and the Book of Abstracts

**Materials Research Society of Serbia**
**&**
**Institute of Technical Sciences of SASA**

2025

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Program and the Book of Abstracts

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## Aim of the Conference

Main aim of the conference is to enable young researchers (post-graduate, master or doctoral student, or a PhD holder younger than 35) working in the field of materials science and engineering, to meet their colleagues and exchange experiences about their research.

## Topics

Biomaterials
Environmental science
Materials for high-technology applications
Materials for new generation solar cells
Nanostructured materials
New synthesis and processing methods
Theoretical modelling of materials

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## Results of the Conference

Beside printed «Program and the Book of Abstracts», which is disseminated to all conference participants, selected and awarded peer-reviewed papers will be published in journal “Tehnika – Novi Materijali”. The best presented papers, suggested by Session Chairpersons and selected by Awards Committee, will be proclaimed at the Closing Ceremony. Part of the award is free-of-charge conference fee at YUCOMAT 2026.

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# Programme
# Twenty-Third Young Researchers Conference
# Materials Science and Engineering

## Wednesday, December 3rd, 2025

**09.15 – 09.30 Opening Ceremony**
**Dr. Ivana Dinić, Dr. Sonja Jovanović, Prof. Dr. Đorđe Veljović, Vice-presidents of 23YRC Sientific committee**

**09.30 – 11.00 1st Session – Biomaterials I**
**Chairpersons: Dr. Ivana Drvenica and Teodora Jakovljević**

**09.30 – 09.45 Hybrid 3D-printed scaffolds containing multi-doped mesoporous bioactive glass as drug-releasing components for bone regeneration**
Teodora Jakovljević[1], Tamara Matić[2], Vukašin Ugrinović[1], Miloš Papić[3], Biljana Ljujić[3], Sanja Petrović[4], Tamara Vlajić Tovilović[4], Milena Radunović[4], Đorđe Veljović[2]
*[1]Innovation Center of the Faculty of Technology and Metallurgy Ltd., Karnegijeva 4, 11000 Belgrade, Serbia, [2]Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, 11000 Belgrade, Serbia, [3]Faculty of Medical Sciences, University of Kragujevac, Svetozara Markovića 69, 34000 Kragujevac, Serbia, [4]Faculty of Dental Medicine, University of Belgrade, Rankeova 4, 11000 Belgrade, Serbia*

**09.45 – 10.00 Optimization of the microemulsion sol-gel method for controlling the composition of mesoporous bioactive glass**
Katarina Vreta[1], Tamara Matić[1], Teodora Jakovljević[2], Đorđe Janaćković[1], Đorđe Veljović[1], Rada Petrović[1]
*[1]Faculty of Technology and Metallurgy, University of Belgrade, [2]Innovation Center of the Faculty of Technology and Metallurgy, Ltd, Belgrade, Serbia*

### 10.00 – 10.15 A 3D osteosarcoma model as a valuable tool for anticancer drug testing

Marija Pavlović[1], Ivana Banićević[1], Milena Milivojević[2], Radmila Janković[3], Jasmina Stojkovska[1], Bojana Obradović[1]
*[1]University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia, [2]University of Belgrade, Institute of Molecular Genetics and Genetic Engineering, Belgrade, Serbia, [3]University of Belgrade, Faculty of Medicine, Belgrade, Serbia*

### 10.15 – 10.30 Development of osteosarcoma 3D *in vitro* model based on alginate and bioactive glasses

Mia Milošević[1,2], Marta Miola[3], Francesco Baino[3], Enrica Verné[3], Radmila Janković[4], Jasmina Stojkovska[1], Bojana Obradović[1]
*[1]University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia,[2]Innovation Centre of the Faculty of Technology and Metallurgy in Belgrade, Belgrade, Serbia, [3]Department of Applied Science and Technology, Politecnico di Torino, Turin, Italy, [4]University of Belgrade, Faculty of Medicine, Belgrade, Serbia*

### 10.30 – 10.45 Foam-replicated 1d bioactive glass scaffolds with interconnected porosity for bone repair

Elnaz Khorasani[1], Maria Erato Pianou[2], Bojana Obradović[1], Enrica Verné[2], Francesco Baino[2]
*[1]University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia, [2]Department of Applied Science and Technology (DISAT), Institute of Materials Physics and Engineering, Politecnico di Torino, Italy*

### 10.45 – 11.00 Vat photopolymerization of polylactic acid/hydroxyapatite scaffolds with a unique combination of structural and compositional gradient for multiple-tissue regeneration

Zahid Abbas[1], Jeevankumar Pallagani[1], Annalisa La Gatta[2], Chiara Schiraldi[2], Paola Palmero[1] and Bartolomeo Coppola[1]
*[1]Politecnico di Torino, Department of Applied Science and Technology, INSTM R.U. Lince Laboratory, Corso Duca Degli Abruzzi, 24, Italy, [2]Department of Experimental Medicine, Section of Biotechnology, University of Campania "Luigi Vanvitelli", 80138 Naples, Italy*

### 11.00 – 11.15 Break

## 11.15 – 13.15 2nd Session – Biomaterials II
## Chairpersons: Prof. Dr. Bojana Obradović and Katarzyna Pastuszak

### 11.15 – 11.30 Biocompatible gold–titanium oxide nanomotors promote ROS-driven cell death in A375 human melanoma cells

Radoš Stefanović[1], Radovan Dojčilović[2], Danijela Danilović[2], Jelena Pajović[3], Vladimir Đoković[2], Tamara Đukić[4], Vesna Ilić[1], Biljana Ristić[1]
*[1]Institute for Medical Research - National Institute of the Republic of Serbia, University of Belgrade, Dr. Subotića 4, PO Box 39, 11129 Belgrade, Serbia, [2]Center of Excellence for Photoconversion, Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, PO Box 522, 11001 Belgrade, Serbia, [3]University of Belgrade, Faculty of Physics, Studentski trg 12, Belgrade 11001, Serbia, [4]Innovation Center of the Faculty of Technology and Metallurgy, Karnegijeva 4, 11120, Belgrade, Serbia*

### 11.30 – 11.45 Non-specific cell labeling using $NaY_{1-x}Gd_xF_4$:Yb/Er up-converting nanoparticles obtained through solvothermal synthesis

Miljana Piljević[1], Ivana Dinić[2], Lidija Mancic[2], Marina Vuković[2], Miloš Tomić[2], Maria Eugenia Rabanal[3], Miloš Lazarević[4], Mihailo D. Rabasović[1]
*[1]Photonic Center, Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, Zemun, 11080, Belgrade, Serbia, [2]Institute of Technical Sciences of SASA, Kneza Mihaila St. 35, 11000, Belgrade, Serbia, [3]Department of Materials Science and Engineering and Chemical Engineering, Universidad Carlos III de Madrid and IAAB, 28903, Madrid, Spain, [4]School of Dental Medicine, University of Belgrade, dr Subotica 8, 11000, Belgrade, Serbia*

### 11.45 – 12.00 Influence of hydrothermal aging on biological properties of the light-cured, CAD-CAM milled and 3D printed dental composites - In vitro study

Nikola Živković[1], Miloš Lazarević[2], Ljiljana Djukić[3], Aleksandar Jakovljević[4], Ivana Dinić[5], Mina Perić[6], Aleksandra Milić Lemić[7]
*[1]Department of Restorative Odontology and Endodontics, School of Dental Medicine, University of Belgrade, Belgrade, Serbia, [2]School of Dental Medicine, University of Belgrade, Belgrade, Serbia, [3]Department of Pharmacology in Dentistry, School of Dental Medicine, University of Belgrade, Serbia, [4]Department of Pathophysiology, School of Dental Medicine, University of Belgrade, Belgrade, Serbia, [5]Institute of Technical Sciences, Serbian Academy of Sciences and Arts, Belgrade, Serbia, [6]Institute of Molecular Genetics and Genetic Engineering, University of Belgrade, Belgrade, Serbia, [7]Department of Prosthodontics, School of Dental Medicine, University of Belgrade, Belgrade, Serbia*

### 12.00 – 12.15 The LL-37 peptide influence on *Legionella longbeachae* model membranes

Katarzyna Pastuszak[1], Małgorzata Jurak[1], Marta Palusińska-Szysz[2]
*[1]Department of Interfacial Phenomena, Institute of Chemical Sciences, Faculty of Chemistry, Maria Curie-Skłodowska University, Maria Curie-Skłodowska Sq. 3, 20-031 Lublin, Poland, [2]Department of Genetics and Microbiology, Institute of Biological Sciences, Faculty of Biology and Biotechnology, Maria Curie-Skłodowska University, Akademicka 19, 20-033 Lublin, Poland*

### 12.15 – 12.30 Antimicrobial activity of composite materials from the calcium-phosphate group with chitosan

Jelisaveta Todorov[1], Milena Pantić[1], Miljana Mirković[2]
*[1]University of Belgrade, Institute for Food Technology and Biochemistry – Faculty of Agriculture, 11080 Belgrade, Serbia, [2]Department of Materials, "VINČA" Institute of Nuclear Sciences—National Institute of the Republic of Serbia, University of Belgrade, Mike Petrovica Alasa 12-14, 11000 Belgrade, Serbia*

### 12.30 – 12.45 Surface-modified metallic biomaterials as systems for localized anticancer effects

Evelina Herendija[1], Milica Jakšić Karišik[2], Marijana R. Pantović Pavlović[3], Miroslav M. Pavlović[3], Olivera Mitrović-Ajtić[4], Nenad L. Ignjatović[5], Miloš Lazarević[2]
*[1]University of Belgrade, Multidisciplinary PhD Studies, Biomedical Engineering and Technology, Studentski Trg 1, 11000, Belgrade, Serbia, [2]University of Belgrade, Faculty of Dental Medicine, Dr Subotića 8, 11000 Belgrade, Serbia, [3]University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Department of Electrochemistry, Njegoševa 12, 11000, Belgrade, Serbia, [4]University of Belgrade, Institute for Medical Research, Department of Molecular Oncology, Dr. Subotića 4, 11129, Belgrade, Serbia, [5]Institute of Technical Sciences of the Serbian Academy of Science and Arts, Knez Mihailova 35/IV, 11000 Belgrade, Serbia*

### 12.45 – 13.00 The influence of siloxane adsorption layers on the hydrophilicity of the Ti-6Al-4V (ELI) surface

Katarzyna Wojdat[1], Joanna Krawczyk[1], Joanna Karasiewicz[2]
*[1]Department of Interfacial Phenomena, Institute of Chemical Sciences, Faculty of Chemistry, Maria Curie-Skłodowska University, Maria Curie-Skłodowska Sq. 3, 20-031 Lublin, Poland, [2]Department of Chemistry and Technology of Silicon Compounds, Faculty of Chemistry, Adam Mickiewicz University, Uniwersytetu Poznańskiego 8, 61-614 Poznań, Poland*

**13.00 – 13.15 Green chemistry unveiled: chitin and chitosan from organic mushroom waste for biomedical applications**

Issam Thamer[1], Magdalena Mazurek-Budzyńska[2], Vignesh Kumaravel[1].
*[1]International Centre for Research on Innovative Biobased Materials (ICRI-BioM) – International Research Agenda, Lodz University of Technology, Żeromskiego 116, Lodz 90-924, Poland, [2]Chair of Polymer Chemistry and Technology, Faculty of Chemistry, Warsaw University of Technology, Noakowskiego 3, 00-664 Warsaw, Poland*

**13.15 – 14.15 Lunch break**

**14.15 – 16.00 3rd Session – Environmental Materials I**
**Chairpersons: Prof. Dr. Ljiljana Damjanović Vasilić and Maša Vračević**

**14.15 – 14.30 Effect of catalyst loading on visible-light degradation of Acid Orange 7 by microwave-synthesized $BiVO_4$ nanoparticles**

Nataša Tot[1], Bojana Vasiljević[1], Dušan Mijin[2], Vesna Despotović[3], Jovana Prekodravac Filipović[1], Dragana Marinković[1]
*[1]Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, P. O. Box 522, 11001 Belgrade, Serbia, [2]Faculty of Technology and Metallurgy, University of Belgrade, Department of Organic Chemistry, Karnegijeva 4, 11000, Belgrade, Serbia, [3]University of Novi Sad Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia*

**14.30 – 14.45 Functional properties of novel self-cleaning materials: multi-analytical in situ and laboratory approach**

Marija Kovač[1], Vesna Miljić[1], Rajko Travica[2], Bojan Miljević[1], Snežana Vučetić[1]
*[1]University of Novi Sad - Faculty of Technology, Bul. cara Lazara 1, 21000 Novi Sad, Serbia, [2]Building company, GP HGP, Put Šajkaškog odreda 8a, 21 000 Novi Sad*

**14.45 – 15.00 Ion exchange membranes for selective separation of metal ions from waste battery solutions**

Maša Vračevič[1,2], Robert Dominko[1,2]
*[1]National institute of Chemistry, Department of Materials Chemistry, D10, Hajdrihova 19, SI-1000, [2]University of Ljubljana, Faculty of Chemistry and Chemical Technology, Večna pot 113, SI-1000*

**15.00 – 15.15 Evaluation of silicone sheets and silicone foam as biomimetic materials for passive sampling of hydrophobic organic compounds in water**
Ivona Sofronievska[1], Marina Stefova[1], Elisa Rojo-Nieto[2]
*[1]Institute of Chemistry, Faculty of Natural Sciences and Mathematics, Ss. Cyril & Methodius University, Skopje, Macedonia, [2]Department of Exposure Science, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany*

**15.15 – 15.30 A green and rapid dispersive liquid–liquid microextraction of $^{137}$Cs using deep eutectic solvents**
Iva Belovezhdova[1,4], Boyan Todorov [1,4], Alina Kalyniukova[2], Vasil Andruch[3], Tanya Yordanova[1]
*[1]Department of Analytical Chemistry, Faculty of Chemistry and Pharmacy, Sofia University "St. Kliment Ohridski", 1164 Sofia, Bulgaria, [2]Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague, 165 00 Prague, Suchdol, Czech Republic, [3]Department of Analytical Chemistry, Institute of Chemistry, Faculty of Science, P. J. Šafárik University, 041 80 Košice, Slovakia, [4]Clean & Circle Center of Competence, Sofia University "St. Kliment Ohridski", 1164 Sofia, Bulgaria*

**15.30 – 15.45 Synthesis and characterization of bioplastics based on corn starch as a sustainable material**
Siniša Mladenović, Snežana Ilić-Stojanović, Milena Nikodijević, Suzana Cakić
*University of Niš, Faculty of Tehnology in Leskovac, Bulevar oslobođenja 124, 16000 Leskovac, Serbia*

**15.45 – 16.00 Investigation on the ferroelectric and photocatalytic properties of lead-free high entropy oxide**
Kevin Varghese Alex[1], Andraž Bradeško[2], Marjeta Maček Kržmanc[3], Slavko Bernik[1], Belisa Alcantara Marinho[1], Miran Čeh[1]
[1]*Department for Nanostructured Materials, Jožef Stefan Institute, Jamova 39, 1000, Ljubljana, Slovenia, [2]Electronic Ceramics Department, Jožef Stefan Institute, Jamova 39, 1000, Ljubljana, Slovenia, [3]Advanced Materials Department, Jožef Stefan Institute, Jamova 39, 1000, Ljubljana, Slovenia*

**16.00 – 16.15 Break**

## 16.15 – 17.45 4th Session – Environmental Materials II

**Chairpersons: Dr. Konrad Terpiłowski and Sara Lukovac**

**16.15 – 16.30 Zn-ZSM5 zeolite oxide coatings with adsorption properties on aluminum**
Marko Dević, Nenad Tadić, Rastko Vasilić
*University of Belgrade, Faculty of Physics, Studentski trg 12-16, 11000 Belgrade, Serbia*

**16.30 – 16.45 Assessment of mechanical and lechability properties of fly ash-based geopolymers loaded with flotation tailing, aluminum slag and spent grit**
Sara Lukovac[1], Nebojša Tadić[2], Dijana Đurović[3], Irena Nikolić[2]
*[1]Institute for interdisciplinary and multidisciplinary studies, University of Montenegro, Cetinjska br. 2, Podgorica, Montenegro, [2]Faculty of Metallurgy and Technology, University of Montenegro, Džordža Vašingtona bb, Podgorica, Montenegro, [3]Centre for Ecotoxicological Research, Bulevar Šarla De Gola 2, Podgorica, Montenegro*

**16.45 – 17.00 Gold(III) recovery from aqueous chloride solutions**
Karolina Zinkowska, Grzegorz Wójcik
*Department of Inorganic Chemistry, Institute of Chemical Sciences, Faculty of Chemistry, Maria Curie-Skłodowska University, Maria Curie-Skłodowska Sq. 2, 20-031 Lublin, Poland*

**17.00 – 17.15 Characterization and potential reuse of dust generated during PP and ABS plastic recycling**
Benita Malinowska[1,2], Konrad Terpiłowski[2]
*[1]Polska Korporacja Recyklingu sp. z o.o., Lublin, Poland, [2]Maria Curie-Sklodowska University, Department of Interfacial Phenomena, Lublin, Poland*

**17.15 – 17.30 Flotation-based separation and recycling of materials from cooling**
Benita Malinowska[1], Konrad Terpiłowski[2], Michał Chodkowski[3]
*[1]Polish Recycling Corporation Ltd., Lublin, Poland, [2]Maria Curie-Skłodowska University, Department of Interfacial Phenomena, Lublin, Poland, [3]Lublin University of Technology, Department of Technology and Processing of Polymers, Lublin, Poland*

### 17.30 – 17.45 Smoke emission studies on glass/polyester laminates modified with bio-based flame retardant

Adriana Dowbysz[1], Mariola Samsonowicz [1], Bożena Kukfisz [2]
*[1]Department of Chemistry, Biology and Biotechnology, Bialystok University of Technology, Wiejska 45E Street, 15-351 Bialystok, Poland, [2]Institute of Safety Engineering, Fire University, 01-629 Warsaw, Poland*

## Thursday, December 4h, 2025

### 09.30 – 11.15 5th Session – Materials for High Technology Application I
### Chairpersons: Prof. Dr. Vuk Radmilović and Nemanja Latas

### 09.30 – 09.45 Investigation of quantitative damage and impurity depth profiles in the case of MgO crystals using the EBS/C technique

Marko Gloginjić[1], Marko Erich[1], Nikola Starčević[1], Stanko Aleksić[1], Michael Kokkoris[2], Stjepko Fazinić[3], Marko Karlušić[3], Nikita Kirilkin[4], Vladimir Skuratov[4], Srdjan Petrović[1]
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### 09.45 – 10.00 Interface-engineered STO thin films on silicon photocathodes for photoelectrochemical hydrogen evolution reaction

Darija Petković[1], Hsin-Chia Ho[2], Janez Kovač[3], Matjaž Spreitzer[2], Lucija Bučar[2], Sonja Jovanović[1], Damjan Vengust[2], Zoran Jovanović[1]
*[1]Laboratory of Physics, Vinča Institute of Nuclear Sciences – National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia, [2]Advanced Materials Department, Jožef Stefan Institute, Ljubljana, Slovenia, [3]Department of Surface Enfineering, Jožef Stefan Institute, Ljubljana, Slovenia*

### 10.00 – 10.15 Reference electrode design and understanding magnesium surface passivation in magnesium-sulfur batteries

Nemanja Latas[1,2], Olivera Lužanin[1], Sara Drvarič Talian[1], Robert Dominko[1,2,3], Alen Vizintin[1]
*[1]Department of Materials Chemistry, National Institute of Chemistry, Hajdrihova ulica 19, 1000 Ljubljana, Slovenia, [2]Faculty of Chemistry and Chemical Technology, University of Ljubljana, Večna pot 113, 1001 Ljubljana, Slovenia, [3]Alistore-European Research Institute, CNRS FR 3104 80039, Amiens, France*

### 10.15 – 10.30 Probing failure mechanisms in solid-state lithium batteries using an integrated micro-reference electrode

Jan Jerovšek[1,2], Sara Drvarič Talian[1], Robert Dominko[1,2]
*[1]Department of Materials Chemistry, National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia, [2]Faculty of Chemistry and Chemical Technology, University of Ljubljana, Večna pot 113, 1000 Ljubljana, Slovenia*

### 10.30 – 10.45 Insights into the operation of microporous carbon hosts in lithium-sulfur batteries

Ivan Dacrema[1,2], Sara Drvarič Talian[1], Robert Dominko[1,2]
*[1]Department of Material Chemistry, National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia, [2]University of Ljubljana, Faculty of Chemistry and Chemical Technology, Večna pot 113, SI-1001 Ljubljana, Slovenia*

### 10.45 – 11.00 Activity and stability analysis of pt-co nanoalloy fuel cell electrocatalyst supported on a hybrid $TiON_x$/GO substrate

Ante Matošin,[1,2] Primož Jovanovič,[1] Léonard Jean Moriau,[1] Francisco Ruiz Zepeda,[1,3] Marjan Bele,[1] Nejc Hodnik[1,3,4]
*[1]National Institute of Chemistry, Hajdrihova 19, 1001 Ljubljana, Slovenia, [2]Faculty of Chemistry and Chemical Technology, Večna pot 113, 1000 Ljubljana, Slovenia, [3]Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia, [4]University of Nova Gorica, Vipavska 13, 5000 Nova Gorica, Slovenia*

### 11.00 – 11.15 Search for a storage phosphor based on YAP for emerging applcations

Yaroslav Zhydachevskyy[1], Vasyl Stasiv[1], Sergii Ubizskii[2], Oleksandr Poshyvak[2]
*[1]Institute for Physics, Polish Academy of Science, Warsaw, Poland, [2]Lviv Polytechnic National University, Lviv, Ukraine*

### 11.15 – 11.30 Break

## 11.30 – 13.00 6th Session – Materials for High-technology Application II
## Chairpersons: Prof. Dr. Rastko Vasilić and Jelena Gojgić

### 11.30 – 11.45 Electrodeposited Co-Sn alloys on Ni mesh as efficient cathodes for alkaline water electrolysis

Jelena D. Gojgić[1], Milena Šetka[2], Lazar Bijelić[2], Thomas Rauscher[3], Christian I. Bernäcker[3], Rastko Vasilić[4], Marjan Bele[2], Milutin Smiljanić[2], Nejc Hodnik[2], Vladimir D. Jović[1], Uroš Lačnjevac[1]

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### 11.45 – 12.00 Infrared thermography as a tool for assessment of thermal effects of RDX-based cast-cured thermobaric composite explosives

Katarina Nestorović[1,2], Danica Bajić[1,2], Mirjana Krstović[1,2], Mladen Timotijević[1], Radoslav Sirovatka[1], Dragan Knežević[1]

*[1]Military Technical Institute, Belgrade, Serbia, [2]University of Defense, Military Academy, Belgrade, Serbia*

### 12.00 – 12.15 Impact of accelerated aging under variable conditions on thermobaric PBX: a vacuum stability test study

Teodora Stančić[1], Mirjana Krstović[1,2], Danica Bajić[1,2]

*[1]Military Technical Institute, Belgrade, Serbia, [2]University of Defense, Military Academy, Belgrade, Serbia*

### 12.15 – 12.30 Monitoring stabilizer consumption in nitrocellulose-based propellants under accelerated aging conditions

Mirjana Krstović[1,2], Teodora Stančić[1]

*[1]Military Technical Institute, Belgrade, Serbia, [2]University of Defense, Military Academy, Belgrade, Serbia*

### 12.30 – 12.45 Sandwich composites reinforced with IF-$WS_2$ nanoparticles and graphene for EMS shielding

Sara Pepić, Olga Maraš, Jelena Gržetić, Jelena Marinković, Vesna Pejović, Radoslav Surla, Danica Bajić

*Military Technical Institute, Ratka Resanovića 1, 11030 Belgrade, Serbia*

**12.45 – 13.00 Oxidation resistance and mechanical properties of hafnium carbonitride ceramics**

Egor Kuzmenko
*Tomsk Polytechnic University, Tomsk, Russia*

**13.00 – 14.00 Lunch break**

**14.00 – 15.30 7th Session – Materials for High-technology Application III and Materials for New Generation Solar Cells**
**Chairpersons: Dr. Marko Opačić and Tea Belojica**

**14.00 – 14.15 Raman signatures of CDW induced phonon folding in $TaTe_4$**

Tea Belojica[1], Jovan Blagojević[1], Marko Opačić[1], Vladimir Damljanović[1], Jelena Pešić[1], Andrijana Šolajić[1], Cedomir Petrovic[2,3,4,5], Ana Milosavljević[1], Nenad Lazarević[1]
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**14.15 – 14.30 Strain-tuned electron–phonon coupling in FeSe**

Jovan Blagojević[1], Ana Milosavljević[1], Tea Belojica[1], Bojana Višić[1,2], Sanja Djurdjić Mijin[1,3], Marko Opačić[1], Andrijana Šolajić[1], Jelena Pešić[1], Novica Paunović[1], Milorad V. Milošević[4], Emil Božin[1,5], Aifeng Wang[5], Cedomir Petrovic[5,6,7,8], Rudi Hackl[9,10], Nenad Lazarević[1]
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*Technische Universität München, 85748 Garching, Germany, [10]IFW Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany*

**14.30 – 14.45 Evidence of temperature-induced lifshitz transition in topological material $ZrTe_5$**

Ana Kanjevac[1], Ana Milosavljević[1], Jasmina Lazarević[1], Jovan Blagojević[1], Qiang Li[2,3], Emil S Božin[1,2], Nenad Lazarević[1]

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**14.45 – 15.00 Raman study of magnetic transitions in $Mn_3Sn_2$**

Gorana Madžarević[1], Ana Kanjevac[2], Jovan Blagojević[2], Jelena Pešić[2], Ana Milosavljević[2] , Nenad Lazarević[2]

*[1]Faculty of Physics, University of Belgrade, Belgrade, Serbia, [2]Center for Solid State Physics and New Materials, Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia*

**15.00 – 15.15 Crystal engineering and humidity response of metal halide perovskite $[Ph_3MeP]_2[CuBr_4]$ single crystals: A combined experimental and theoretical approach**

Dinesh Kulhary, Arun Sharma

*Department of Chemistry, Career Point University, Kota, India-325003*

**15.15 – 15.30 Comprehensive investigation of environmental degradation pathways and stability enhancement in $FAPbI_3$ perovskite films incorporating polyionic liquid (PIL) additives**

Barbara Ramadani[1], Vladimir Rajić[1], Miloš Milović[1], Daniele Mantione[2], Milutin Ivanović[1]

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**15.30 – 15.45 Break**

## 15.45– 17.30 8th Session – New Synthesis and Processing Methods
## Chairpersons: Dr. Sonja Jovanović and Aleksandar Petričević

### 15.45 – 16.00 Thin film heterostructures by reactive sputtering: from interface engineering to defect control

Jelena P. Georgijević[1], Nemanja Latas[2], Nikola Cvjetićanin[3], Dejan Pjević[1]
*[1]Department of Atomic Physics, INS Vinča—National Institute of the Republic of Serbia, University of Belgrade, Mike Petrovića Alasa 12-14, 11351 Belgrade, Serbia, [2]Department of Materials Chemistry, National Institute of Chemistry, Ljubljana, Slovenia, [3]Faculty of Physical Chemistry, University of Belgrade, Serbia*

### 16.00 – 16.15 Optimization of electrochemical deposition parameters for nimoo$_x$ electrocatalysts for the hydrogen evolution reaction

Aleksandar Petričević[1], Mila Krstajić Pajić [2], Piotr Zabinski[3], Dawid Kutyla[3], Mateus Marzec[4], Marta Gajewska[4], Nevenka Elezović[1], Vladimir Jović[1]
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### 16.15 – 16.30 Enhancing solubility of ellagic acid from raspberry biomass using ionic liquids

Jelena Jovanović[1], Dajana Lazarević[1], Nada Ćujić Nikolić[2], Petar Ristivojević[3], Tatjana Trtić-Petrović[1]
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### 16.30 – 16.45 Chemical characterization and cytotoxic profile of cocoa bean shell (*Theobroma cacao L.)* extract as a potential cosmetic ingredient

Sandra Rakin[1], Aleksandra Jovanović[1], Milica Jovanović Krivokuća[1], Maja Bulatović[2], Danica Zarić[3], Marica Rakin[2]
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### 16.45 – 17.00 pH- Responsive anthocyanin–biopolymer films as smart food freshness indicators

Marija Botić[1], Sanja Perać[1], Jelena Jovanović[1], Ana Žugić[2], Vanja Tadić[2], Goran Branković[1], Zorica Branković[1]
*[1]University of Belgrade – Institute for Multidisciplinary Research, Belgrade, Serbia, [2]Institute for Medicinal Plants Research "Dr. Josif Pančić", Belgrade, Serbia*

### 17.00 – 17.15 Application of the briggs-rauscher oscillatory reaction for the identification of phosphate-tungsten bronzes

Tijana Maksimović[1], Jelena Maksimović[2], Zoran Nedić[3], Dimitrije Mara[4], Rik van Deun[5], Pavle Tančić[6], Ljubinka Joksović[1], Maja Pagnacco[6]
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### 17.15 – 17.30 New poly(carboxy-)/poly(sulfobetaine methacrylate) based materials as transdermal patches for quinine hydrochloride delivery

Denitsa Nikolova, Eleva Vassileva
*[1]Laboratory on Structure and Properties of Polymers, Faculty of Chemistry and Pharmacy, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria*

## Friday, December 5th, 2025

### 09.30 – 11.00 9th Session – Theoretical Modelling and Nanostructured Materials I

**Chairpersons: Dr. Zoran Jovanović and Ena Todorović**

**09.30 – 09.45 Theoretical prediction and experimental validation of temperature-dependent raman spectra of doxorubicin**

Ena Todorović[1], Sylwia Orzechowska[2], Milan Milovanović[1], Jelena Pešić[3], Malgorzata Baranska[2], Jasmina Lazarević[3], Nenad Lazarević[3]

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**09.45 – 10.00 Unveiling new spin states in NiO and PdO: a computational exploration of polymorphism**

R. Bujdák[1], D. Fabušová[1], K. Tokár[1,2], M. Derzsi[1], Z. Száraz[1]

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**10.00 – 10.15 Vibrational properties of $SrIrO_3$ thin films grown on various substrates**

Marko Opačić[1], Nataša Tomić[1], Luis Balcells[2], Benjamin Martinez[2], Alberto Pomar[2], Maja Šćepanović[1], Zorica Konstantinović[1]

*[1]Center for Solid State Physics and New Materials, Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia, [2]Instituto de Ciencia de Materiales de Barcelona, ICMAB-CSIC, Campus Universitario UAB, Bellaterra 08193,
Spain*

**10.15 – 10.30 Epitaxial growth of monocrystalline palladium oxide nanoparticles on rutile substrates**

Filip Ferenčík[1], Viliam Vretenár[2], Diana Fabušová[1], Pavol Noga[2]

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[2]Centre for Nanodiagnostics of Materials, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava, Vazovova 5, Bratislava, 81243, Slovakia*

**10.30 –10.45 Influence of different modification and functionalization strategies of graphene quantum dots on singlet oxygen production**

Mila Milenković, Svetlana Jovanović
*Vinca Institute of Nuclear Sciences – National Institute of the Republic of Serbia, University of Belgrade, P.O. Box 522, 11000 Belgrade, Serbia*

**10.45 – 11.00 Polystyrene nanosized dots: Structure and optical properties**

Vanja G. Ćirić[1], Biljana M. Todorović Marković[1], Zoran M. Marković[1]
*[1]Vinča Institute of Nuclear Sciences, National Institute of the RS, University of Belgrade, Mike Petrovića Alasa 12-14, 11001 Belgrade, Serbia*

**11.00 – 11.15 Break**

**11.15 – 13.00 10th Session – Nanostructured Materials II**
**Chairpersons: Dr. Lidija Mančić and Dr. Željko Mravik**

**11.15 – 11.30 Influence of synthesis route on the supercapacitor performance of graphene oxide-based composites**

Željko Mravik[1,2], Sonja Jovanović[1], Marija Milićević[1], Marko Jelić[1], Jelena Rmuš Mravik[1,2], Milica Milanković[1], Zoran Jovanović[1,2]
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**11.30 – 11.45 Oxidation methods of single-walled carbon nanotubes**

Natalija Janković*[1], Ivana Borišev[1], Branimir Bajac[2], Aleksandar Đorđević[1]
**Undergraduate student, Faculty of Sciences, University of Novi Sad, [1]Department of Chemistry, Biochemistry and Environmental Protection, Faculty of Sciences, University of Novi Sad, Serbia, [2]BioSense Institute, University of Novi Sad, Serbia*

**11.45 – 12.00 Investigating structural and optical properties of $Eu^{3+}$-doped $MgGd_2Zr_2O_8$ for application in optical thermometry**

Andrijana Pantelić[1], Vesna Lojpur[1], Miloš Milović[1], Ljiljana Veselinović[2], Miloš Tomić[2], Lidija Mančić[2], Tijana Stamenković[1]
*[1]Institute of Nuclear Sciences, Vinča, National Institute of the Republic of Serbia, University of Belgrade, 11351 Belgrade, Serbia, [2]Institute of Technical Sciences of SASA, 11000 Belgrade, Serbia*

**12.00 – 12.15 Influence of the graphene oxide content in the ZnO/GO composite on the selectivity and sensitivity of the electrode for detecting diclofenac in water**

Ana Nastasić[1], Kristina Gočanin[2], Katarina Aleksić[3], Marijana Kraljić Roković[4], Smilja Marković[3], Ivana Stojković Simatović[2]
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**12.15 – 12.30 Detection of doxorubicin from aqueous solution using ZnO/BaTiO$_3$-based nanocomposites**

Kristina Spasić[1], Katarina Aleksić[2], Smilja Marković[2], Ivana Stojković Simatović[1]
[1]*Faculty of Physical Chemistry, University of Belgrade, Belgrade, Serbia,* [2]*Institute of Technical Sciences of SASA, Belgrade, Serbia*

**12.30 – 12.45 Vendor presentation**
**Tevus d.o.o / Sympatec GmbH and Edinburgh instruments** (Mr. Peđa Srejić)
*Tevus d.o.o., Velisava Vulovića 20, 11000 Belgrade, Serbia*

**12.45 – 13.00 Vendor presentation**
**MeriMeri / Bettersize instruments** (Mr. Ivan Lazić)
*MeriMeri d.o.o., Peđe Milosavljevića 34, 11070 Belgrade, Serbia*

**13.00 – 14.00 Lunch break**

## 14.00 – 15.30 11th Session – Nanostructured Materials III
## Chairpersons: Prof. Dr. Ivana Stojković Simatović and Ivan Pešić

### 14.00 – 14.15 Exploration of electrodeposited carbon as a cathode for fully self-powered Al-air battery-based humidity sensor

Olivera Živković[1], Katarina Cvetanović[1], Milče M. Smiljanić[1], Evgenija Milinković[1], Danica Bajuk-Bogdanović[2], Marko V. Bošković[1]
*[1]Institute of Chemistry, Technology, and Metallurgy, Department of Microelectronic Technologies, Njegoševa 12, 11000 Belgrade, Serbia, [2]University of Belgrade, Faculty of Physical Chemistry, Studentski trg 12-16, Belgrade 11158, Serbia*

### 14.15 – 14.30 Synthesis, properties and electrochemical performances of novel pure and functionalized niobium MXenes

Ivan Pešić[1], Nemanja Gavrilov[2], Andjela Gavran[1], Katarina Tošić[1], Vanja Vojnović[1], Marko Spasenović[1], Marija Pergal[1]
*[1]Center for Microelectronic Technologies, Institute of Chemistry, Technology and Metallurgy, National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia, [2]Faculty of Physical Chemistry, University of Belgrade, Belgrade, Serbia*

### 14.30 – 14.45 Stabilizing $WSe_2$ against uv-induced oxidation using thin hbn encapsulation layers

Lidija Vulićević, Tijana Tomašević Ilić, Jelena Pešić
*Center for Solid State Physics and New Materials, Institute of Physics Belgrade, Pregrevica 118, 11080 Zemun, Belgrade, Serbia*

### 14.45 – 15.00 CQDs as antibacterial photoactive agents in polyurethane coating

Ana Marković[1], Ana Popović Bijelić[2], Marija Mojsin[3], Janez Kovač[4], Jaroslav Kuliček[5], Vladimir Pavlović[6], Biljana Todorović Marković[1], Zoran Marković[1]
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### 15.00 – 15.15 Microwave-assisted synthesis of carbon quantum dots for adsorption applications

Jelena Kozić, Jovana Filipović Prekodravac, Biljana Todorović Marković
*Vinca Institute of Nuclear Sciences-National Institute of the Republic of Serbia, University of Belgrade, Mike Petrovića Alasa 12-14, 11000 Belgrade, Serbia*

### 15.15 – 15.30 $Cu^2$@$SiO_2$ nanocomposites for antimicrobial surfaces

Aadil Shafi Bhat[1], Alexander Vanetsev[1], Vambola Kisand[1], Angela Ivask[2], Mati Kook[1], Hugo Mändar[1], Kaja Kasemets[3], Mariliis Sihtmäe[3]
*[1]Institute of Physics, University of Tartu W. Ostwaldi 1, 50411 Tartu, Estonia, [2]Institute of Molecular and Cell Biology, University of Tartu, Riia 23, 51010 Tartu, Estonia, [3]Laboratory of Environmental Toxicology, National Institute of Chemical Physics and Biophysics, Akadeemia tee 23, 12618 Tallinn, Estonia*

### 15.30 Closing Ceremony

1-1

# Hybrid 3D-printed scaffolds containing multi-doped mesoporous bioactive glass as drug-releasing components for bone regeneration

Teodora Jakovljević[1], Tamara Matić [2], Vukašin Ugrinović[1], Miloš Papić[3], Biljana Ljujić[3], Sanja Petrović[4], Tamara Vlajić Tovilović[4], Milena Radunović[4], Đorđe Veljović[2]

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Ongoing efforts focus on optimizing the microemulsion-assisted sol–gel (ME-SG) process to produce ion-doped bioactive glass particles with tunable structural, physicochemical, and biological properties, offering excellent potential for drug loading, controlled release, and integration into scaffolds for regenerative medicine. 3D-printing via mask-stereolithography (mSLA) enables fabrication of scaffolds with precise geometry and internal architecture but requires rapidly crosslinking resins. Incorporating ceramic particles affects resin viscosity and photopolymerization behavior, making tailored composite formulations essential for successful mSLA scaffold processing. In this study, multi-doped MBG particles ($70SiO_2$–$20CaO$–$3MgO$–$5SrO$–$1CuO$–$1ZnO$, mol.%) were synthesized via a modified ME-SG method via ultrasound and successfully loaded with ciprofloxacin. Upon characterization, the particles were incorporated into a photopolymerizable resin containing polyethylene glycol diacrylate, methacrylic acid, and gelatin, and used to 3D print macroporous scaffolds via mSLA. The scaffolds were further modified with chitosan/MBG/ciprofloxacin coatings to modulate mechanical and antimicrobial properties. Spherical MBG particles (~300 nm) with confirmed dopant incorporation and an amorphous, mesoporous structure with high specific surface area were obtained. Biocompatibility tests showed high cell viability, low apoptosis, and minimal necrosis, while ciprofloxacin-loaded MBGs exhibited sustained drug release, and complete inhibition of *Staphylococcus aureus* growth. Incorporation of MBGs in the polymer resin increased surface roughness of 3D-printed scaffolds. Furthermore, scaffold coatings influenced porosity, mechanical and antibacterial properties, with chitosan/MBG and chitosan/MBG/ciprofloxacin coatings demonstrating strong antimicrobial effects against *Staphylococcus aureus*. Overall, these results demonstrate that multi-doped MBG particles can be effectively integrated into 3D-printed scaffolds, providing tunable physicochemical, biological, and antibacterial properties, making them promising candidates for bone tissue engineering and drug delivery.

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1-2

# Optimization of the microemulsion sol-gel method for controlling the composition of mesoporous bioactive glass

Katarina Vreta[1], Tamara Matić[1], Teodora Jakovljević[2], Đorđe Janaćković[1], Đorđe Veljović[1], Rada Petrović[1]

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Due to their bioactive properties and ability to enable controlled release of therapeutic ions and bioactive substances, mesoporous bioactive $SiO_2$-CaO glasses (MBG) represent one of the most promising biomaterials in regenerative medicine. MBGs with spherical particles and narrow size distribution are most commonly synthesized using the microemulsion sol-gel method, where the surfactant molecules play a key role in the development of the characteristic porous structure. In addition to calcium ions, which play a key role in their bioactivity, the incorporation of therapeutic ions such as $Zn^{2+}$, $Cu^{2+}$, $Mg^{2+}$, and $Sr^{2+}$ enhances angiogenic, osteogenic, and antibacterial properties of MBGs. However, previous studies have shown substantial discrepancies between the actual and nominal compositions, particularly regarding the calcium content. The aim of this study was to improve the standard microemulsion sol-gel method to incorporate the desired amount of ions into the silicate structure while maintaining the characteristic MBG morphology. Two modifications types were investigated: one involved maintaining a constant pH during the synthesis, while the second involved post-synthetic metal ion impregnation followed by two drying methods: conventional and lyophilization. As a control, MBG synthesized by the standard microemulsion sol-gel method was used. The characterization of the synthesized powders included a detailed analysis of the composition, morphology, and textural properties of the obtained particles. The results showed that in all cases, spherical particles with the characteristic porosity were formed. Maintaining a constant pH value led to an increase in particle size and a decrease in the specific surface area, as well as improved incorporation of $Ca^{2+}$ ions, while the impact on the incorporation of other ions was minimal. The process modification, which resulted in smaller particles and a reduced specific surface area, showed significant improvements in achieving the desired composition. Additionally, it was shown that the drying method influenced the glass structure, with lyophilization preventing the formation of undesired crystalline phases.

**Acknowledgments:** This research was funded by the Science Fund of Republic of Serbia #GRANT No.7470, Novel hybrid biomimetic macroporous composites with tuned biodegradability, improved osteointegration and anticancer properties for bone tissue regeneration – HyBioComBone and by Ministry of Science, Technological Development and Innovations, Republic of Serbia (No. 451-03-136/2025-03/200135, 451-03-136/2025-03/200287)

1-3

# A 3D osteosarcoma model as a valuable tool for anticancer drug testing

Marija Pavlović[1], Ivana Banićević[1], Milena Milivojević[2], Radmila Janković[3],
Jasmina Stojkovska[1], Bojana Obradović[1]

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Osteosarcoma, a primary malignant bone tumor, still remains very difficult to cure despite the variety of available complex therapeutic approaches. One of the reasons is the slow and demanding process of validation of new drugs, which is significantly limited by the lack of adequate and reliable preclinical models. In this work, a previously developed three-dimensional (3D) osteosarcoma cell culture model was evaluated for the use in short- and long-term studies of anticancer drug effects. The model combined the application of macroporous composite scaffolds composed of alginate (2 wt.%), mimicking the organic, and hydroxyapatite particles (2 wt.%), mimicking the inorganic phase of bone, and a perfusion bioreactor system providing enhanced mass transport and adequate biophysical signals. In all experiments, murine osteosarcoma cells (K7M2-wt) were seeded onto the scaffolds ($15 \times 10^6$ cells $cm^{-3}$), with a seeding efficiency higher than 90%. After seeding, the cells were cultured under static conditions for one day to allow adhesion and adaptation to the scaffold. Next, in all experiments the scaffolds were cultured under continuous medium flow (0.27 $cm^3$/min; superficial velocity of 40 μm/s) in a perfusion bioreactor "3D Perfuse" (Innovation Center of Faculty of Technology and Metallurgy, Belgrade, Serbia) with or without application of anticancer drug doxorubicin (1 μg/ml) for different periods of time in order to investigate the drug effects on individual and loosely aggregated cells as well as on spheroid-like structures formed after 7 days of bioreactor cultivation. In specific, in the first two experimental series the treatment lasted for 1 and 3 days immediately after the static culture, while in the following two experimental series the treatment was applied at day 8 of the bioreactor culture and lasted for 1 and 3 days. In a separate experimental series, the 3-day treatment of individual cells (as in experiment 2) was followed by a 21-day recovery period under medium flow. The cultivated scaffolds were assessed by histological analysis and MTT assay to determine cell morphology and metabolic activity, respectively. The results showed that the 1-day treatment had negligible effects, while the 3-day treatment significantly affected individual cells, but not spheroids. In the long-term study following the 3-day treatment of individual cells, the metabolic activity of treated samples remained low after 21 days of recovery, whereas control samples (untreated) showed higher activity with a gradual decline. These results indicate that the developed 3D osteosarcoma model can be potentially used for both short- and long- term studies of new drugs, providing a valuable tool for preclinical testing of anticancer therapies.

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1-4

# Development of osteosarcoma 3D *in vitro* model based on alginate and bioactive glasses

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Three-dimensional (3D) *in vitro* models are gaining attention of researchers because they can mimic some of the key disease properties and offer reliable and reproducible results. Osteosarcoma is a primary tumour originating in bones, so that an osteosarcoma 3D *in vitro* model should imitate the structure and composition of this tissue and support cancer cell behaviour observed *in vivo*. One of the approaches is to use macroporous composite scaffolds based on organic polymers with incorporated mineral particles as cell carriers. The focus of this work was to develop two types of alginate-based scaffolds with the addition of two different bioactive glasses (BAG): SBA2 (composition: $48SiO_2$-$18Na_2O$-30CaO-$3P_2O_5$-$0.43B_2O_3$-$0.57Al_2O_3$ mol%) and 47.5B (composition: $47.5SiO_2$-$10Na_2O$-$10K_2O$-10MgO-20CaO-$2.5P_2O_5$ mol.%). Two series of hydrogels composed of 2 wt.% alginate, 2 wt.% BAG and 0.045-0.075 wt.% $CaCl_2$ were produced under controlled gelation process, followed by freezing and freeze-drying and the obtained scaffolds were characterized in terms of porosity and mechanical properties. Both scaffold types had similar porosities in the range 50-67%, similar to that of trabecular bone. Scaffolds based on BAG 47.5B showed better pore distribution and slightly higher, but not statistically significantly different Young's compression moduli compared to those of SBA2-based scaffolds (93±18 kPa *vs.* 81±18 kPa, respectively). In the next phase, the optimal composition was selected for both scaffold types (2 wt.% alginate, 2 wt.% BAG and 0.060 wt.% $CaCl_2$) and these scaffolds were used in short-term cultivation studies of murine osteosarcoma cell line *K7M2-wt*. Scaffolds based on BAG 47.5B enabled higher cell seeding efficiency (92%) compared to that of SBA2-based scaffold (72%). Still, both scaffold types supported cell viability over 7 days of cultivation and viable cell aggregate formation, as confirmed by histological analysis. This finding implies correspondence to osteosarcoma tumours observed *in vivo*. All the obtained results indicate that the developed scaffolds support biomimetic osteosarcoma cell culture, with 47.5B-based scaffolds offering superior porosity and cell seeding efficiency.

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1-5

# Foam-replicated 1d bioactive glass scaffolds with interconnected porosity for bone repair

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This study aims to create highly porous, interconnected bone scaffolds by replicating the structure of polyurethane foams with a bioactive silicate glass from the 1d system. The research also focuses on developing a concise, testable workflow that links microstructure, mass transport, and mechanical behavior. Upon heating, the 1d glass crystallizes into fluorapatite, wollastonite, and diopside glass-ceramic phases, which are notable for their mechanical strength and bioactivity.The 1d bioactive glass was made by melting oxide and carbonate precursors, followed by crushing, milling, and sieving the material to particles smaller than 25 mm. Cylindrical polyurethane foams were cut to the same size (approximately 9 mm in diameter, 9 mm height) and used as templates. A solution containing polyvinyl alcohol (PVA) as a binder and water was heated and mixed with the glass powder (final composition: 9 g glass, 1.8 g PVA, 19.2 g $H_2O$) to make a homogeneous slurry. In this work, a consistent slurry and impregnation process has been established. In early tests, it was determined that the slurry needs to be heated to 90 °C to fully dissolve the PVA before adding the glass, resulting in a homogeneous suspension that allowed for even coating of the polymeric template. In specific, each foam was coated through three cycles of dipping and gentle compression, pressing to about two-thirds of its diameter and rotating 90° between steps to remove extra slurry and ensure even coverage of polymer struts/walls. The samples were dried on non-absorbent paper, turned regularly, then heated to burn out the polymer (300 to 600 °C) and sintered at 1000 °C for 3 h to form a porous, interconnected glass-ceramic scaffold. Forty-seven polyurethane templates have been shaped. The obtained scaffolds are being characterized by X-ray diffraction (XRD), scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS), micro-computed tomography (micro-CT), and uniaxial compression testing. In addition, it is planned to assess permeability by using a pressure-wave drop method with alternating airflow. These measurements will be used to correlate effective porosity, pore size (approximately 200–700 μm), and tortuosity with intrinsic permeability. The presented foam replication process using 1d glass provides a practical approach for producing scaffolds with trabecular-like architecture. The planned characterization set of micro-computed tomography, permeability, and mechanical testing is expected to elucidate how sintering and slurry parameters influence mass transport and mechanical strength.

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1-6

# Vat photopolymerization of polylactic acid/hydroxyapatite scaffolds with a unique combination of structural and compositional gradient for multiple-tissue regeneration

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Digital Light Processing (DLP) is a promising approach to fabricate scaffolds with structural and compositional gradients tailored to site-specific tissue properties. In this study, both uniformly dense and gyroid samples as well as structurally graded gyroid scaffolds were designed based on triply periodic minimal surfaces (TPMS) and fabricated by DLP using polylactic acid/hydroxyapatite (PLA/HA) composite slurries. Ultrafine HA powders were added to a commercial PLA resin at 35 wt%, and 55 wt%. To produce graded samples, these two slurries were blended in specific ratios (42 and 48 wt%) using a multi-head peristaltic pump, feeding the printer with progressively higher HA contents. Rheological and curing depth tests confirmed good printability across all slurry compositions, including the highest HA loading. The feasibility of the approach was first demonstrated using dense cylindrical specimens. Microstructural and elemental analyses confirmed the desired compositional gradient, while physical and mechanical tests showed that graded samples had intermediate density, compressive strength, and modulus compared to uniform reference samples. This approach was further applied to gyroid-type scaffolds, which also demonstrated smooth compositional transitions and similar intermediate mechanical behavior. Preliminary biological assessments confirmed no cytotoxic effects for both neat PLA and PLA/HA composites. Finally, leveraging the variable HA content slurry, a compositionally and structurally graded PLA/HA gyroid scaffold was printed for the first time, demonstrating the feasibility of the strategy to obtain scaffolds potentially customizable for any type of complex and multilayered anatomical defects.

2-1

# Biocompatible gold–titanium oxide nanomotors promote ROS-driven cell death in A375 human melanoma cells

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Light-driven metal-oxide nanomotors are emerging as promising tools for efficient tumor penetration and intracellular drug delivery, offering enhanced antitumor activity. Titanium oxide nanomotors can overcome tumor microenvironmental barriers under light irradiation and propel themselves using tumor-derived $H_2O_2$. Their mobility improves cellular uptake and therapeutic efficacy, however, the precise mechanisms underlying their antitumor activity remain unclear. Here, we explored the cytotoxicity of newly developed gold–titanium oxide ($AuTiO_2$) nanomotors on A375 human melanoma cells, focusing on their effects on cell viability, morphology, and cell death pathways. To assess the biological effects of $AuTiO_2$nanomotors, cell viability was measured by MTT assay, revealing dose-dependent cytotoxicity (0.5-10 µg/ml) after 24h. Phase-contrast microscopy showed morphological changes consistent with cell death. Flow cytometry analyses confirmed apoptosis as the predominant pathway, showing increased Annexin $V^+$ and Annexin $V^+/PI^+$ cells, elevated intracellular ROS detected with the ROS-sensitive dye DCFDA, and caspase involvement verified by inhibition with Apostat. Additionally, the hemolysis test showed no adverse effects on red blood cells after 3 hours of incubation, suggesting that the application of the nanomotors is unlikely to induce intravascular hemolysis, and can be further assessed for biocompatibility. Collectively, these findings demonstrate that $AuTiO_2$ nanomotors effectively induce ROS-driven, caspase-dependent apoptosis in A375 melanoma cells while exhibiting minimal toxicity toward red blood cells. Together, the results highlight the potential of $AuTiO_2$ nanomotors as a potent strategy for targeted anti-melanoma therapy.

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2-2

# Non-specific cell labeling using $NaY_{1-x}Gd_xF_4$:Yb/Er up-converting nanoparticles obtained through solvothermal synthesis

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Lanthanide-doped up-converting nanoparticles (UCNPs), due to their advantages over currently used fluorophores, show a significant potential in biomedical sciences as probes for early cancer detection. Their use enables deep noninvasive tissue imaging, since they can emit visible or ultraviolet light upon excitation by near-infrared light, which has lower phototoxicity and higher tissue penetration depth in living systems compared to visible or ultraviolet light. There are several methods for synthesis of these nanoparticles, and in this study chitosan assisted solvothermal approach was applied for the synthesis of $NaY_{1-x}Gd_xF_4$:Yb/Er nanoparticles. This environmentally friendly method is rapid and low cost and produces biocompatible nanoparticles. Following the synthesis, techniques for characterizing the properties of UCNPs, such as size, shape, phase and optical properties, were performed: X-ray powder diffraction, scanning and transmission electron microscopy, Fourier transform infrared spectroscopy and photoluminescence spectroscopy. Two types of cells were used for cell labeling: HS-5 fibroblast cell line and SCC–25 oral cancer cell line, and the cytotoxicity test was done to assess the biological safety of UCNPs. After the incubation of cells with UCNPs, Nonlinear Laser Scanning Microscopy was performed to check the potential of obtained UCNPs to label cells under irradiadion of Ti:Sapphire laser (Coherent, Mira 900-F) as a laser light source. For the imaging of cells autofluorescence excitation wavelength of 730 nm in femtosecond mode was applied, while for detection of UCNPs 976 nm in continuous wave mode was used. The images have shown that the UCNPs were located adjacent to the plasma membrane in the cytoplasmic region of both healthy and cancer cell lines, as well that the cells retained their original morphology. Additionally, the nanoparticles were further analyzed in order to check their potential for optical thermometry and results revealed that the synthesized nanoparticles could be used for measuring the temperature in tissues.

2-3

# Influence of hydrothermal aging on biological properties of the light-cured, CAD-CAM milled and 3D printed dental composites- *In vitro* study

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In contemporary restorative dentistry, fabrication of composite restorations relies on three principal technologies: direct- light-curing, subtractive-milling, and additive 3D printing. It is well established that direct light-cured composite resins do not achieve complete polymerization, resulting in potential unreacted monomers diffusion through dentinal tubules toward the pulp tissue. Recently introduced 3D-printed composite resins contain a higher proportion of organic matrix to inorganic fillers, which may adversely affect their biological characteristics and overall biocompatibility. Therefore, the aim of the present work is to evaluate and compare biological properties of light cured (LC), CAD-CAM-milled (MC) and 3D printed (PC) dental composites before and after hydrothermal aging. Disc-shaped specimens of each material were fabricated and subjected to four aging protocols: unaged (T0), or thermocycled for 5,000 (T1), 10,000 (T2), or 30,000 cycles (T3). The experimental analysis included cell viability assays and live/dead fluorescent microscopy using human gingival fibroblasts (HGFs), assessment of inflammatory response (IL-6 and PGE2), and oxidative stress(total antioxidant status (TAS), total oxidant status (TOS), and oxidative stress index (OSI). Fourier Transform Infrared (FTIR) spectroscopy was performed to evaluate the surface chemistry and of tested materials.All materials showed acceptable cell viability (>70%). LC displayed the greatest variability after aging, MC remained stable, and PC achieved the highest biocompatibility with minimal inflammatory and oxidative responses. FTIR analysis indicated a more advanced polymer network and fewer unreacted groups in PC and MC, suggesting superior polymerization and long-term stability compared to LC.Overall, the results indicate that both the manufacturing technique and material composition critically determine the biological performance of dental composites, with PC exhibiting the highest stability and most consistent biocompatibility under aging conditions.

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2-4

# The LL-37 peptide influence on *Legionella longbeachae* model membranes

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*Legionella longbeachae* bacteria cause respiratory infections that can be fatal in immunocompromised individuals. The structure of cell membranes containing phospholipids determines both the direct interactions of bacteria with host cells and the pathogenicity of the microorganism. Due to the adaptive abilities, *L. longbeachae* strains resistant to antibiotics, commonly used for Legionellosis treatment, are emerging. Moreover, during the infection in human lungs, *Legionella* bacteria utilize choline derived from pulmonary surfactant to modify their membranes' composition, and thus alter the susceptibility to antimicrobial agents. Therefore, new therapeutic substances that could combat bacterial infections are being sought. Antimicrobial peptides naturally occurring in the human body, such as human cathelicidin (LL-37 peptide), are of particular interest. This peptide, synthesized by epithelial cells, leukocytes, and macrophages, exhibits immunomodulatory and antimicrobial activity. LL-37 is able to interact with the phospholipids that build bacterial membranes, which can lead to changes in their organization, disruption of proper functioning, and ultimately, death of the microorganism. The presented study aimed to determine the effect of the LL-37 peptide on model *L. longbeachae* membranes, composed of phospholipids isolated from these bacteria cultured on a medium supplemented or not supplemented with choline. Model bacterial membranes were formed using the Langmuir monolayer technique, and the dependence of surface pressure on the average surface area per molecule ($\pi$-A isotherms) during compression was recorded. Simultaneously, surface morphology images were taken using Brewster angle microscopy (BAM). The results of the analyses demonstrated a significant LL-37 effect on the organization of phospholipid molecules at the interface. Model *L. longbeachae* membranes in the presence of the peptide, in comparison to the monolayers formed without the addition of LL-37, were characterized by lower stability, greater flexibility, and altered surface morphology.

2-5

# Antimicrobial activity of composite materials from the calcium-phosphate group with chitosan

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In this study, the antimicrobial activity of calcium phosphate-based materials was investigated. The materials that were used were hydroxyapatite (HAp), strontium-doped hydroxyapatite (SrHAp), and octacalcium phosphate (OCP). All samples were synthesized by wet-chemical precipitation, and their characterization was performed using FTIR, SEM, and X-ray diffraction (XRD). In addition, composites of all samples were prepared using commercial low-molecular-weight chitosan (50–190 kDa) with a high degree of deacetylation (75–85%). This work aimed to determine the antimicrobial activity of the individual materials and identify which calcium phosphate materials, in combination with chitosan, exhibit the best antimicrobial activity. Antimicrobial tests were conducted against Salmonella Enteritidis and *Candida albicans*. The results showed that pure hydroxyapatite exhibited the most potent antimicrobial activity against *S. Enteritidis*, whereas strontium doping reduced this activity. In contrast, the best activity against *C. albicans* was observed for OCP, whereas the combination of SrHAp and chitosan showed the weakest effect. The results indicate that chemical modification of hydroxyapatite significantly affects its antimicrobial activity, and that combining it with chitosan can yield composites with excellent antimicrobial properties, making them potential candidates for the development of various biomaterials.

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2-6

## Surface-modified metallic biomaterials as systems for localized anticancer effects

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Surface modification of metallic biomaterials offers a promising strategy to enhance therapeutic potential of multifunctional implants through interaction with the biological environment. In this study, we developed a bioactive titanium (Ti) surface with anticancer activity against oral squamous cell carcinoma cells (OSCC). A combined anodizing/anaphoretic electrodeposition technique was applied, and a coated titanium composite-Ti/Coating system with nano-hydroxyapatite (nHAp), chitosan-oligolactate (ChOL), and selenite (Se) was fabricated with improved biological functionality. Our results showed that the Ti/Coating significantly reduced cell viability and induced early apoptosis, compared to uncoated titanium. Elevated intracellular ROS levels, nanoparticle uptake, and apoptosis-associated gene modulation (BAX upregulation and BCL2 downregulation) were observed. Additionally, the Ti/Coating suppressed EMT markers (VIM, SLUG, SNAIL), downregulated oncogenic signaling (AKT/mTOR, Wnt/β-catenin), and reduced cell migration. These findings highlight the potential of bioactive, surface-engineered titanium implants to provide localized anticancer activity, particularly in postoperative therapy.

2-7

# The influence of siloxane adsorption layers on the hydrophilicity of the Ti-6Al-4V (ELI) surface

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Biomaterials are capable of being in the direct contact with the tissues of a living organism. There are five groups of biomaterials: metallic biomaterials, carbon biomaterials, bioceramics, biopolymers and composite biomaterials. One of the most commonly used metallic biomaterials in medicine is the Ti-6Al-4V (ELI) alloy. This is due to its large biocompatibility, which is caused by the ability of titanium and its alloys to passivate spontaneously in contact with oxygen. Titanium alloys are covered with a passivation layer in contact with air. This layer is formed by the mixture of titanium, aluminium and vanadium oxides. For this reason, titanium alloys are less biocompatible than pure titanium. Due to smaller biocompatibility of titanium alloys, their surface properties modification is an important way in biomaterials engineering. To modify the surface of titanium alloys one way is to apply various types of adsorption layers. This allows the hydrophilic and hydrophobic properties of the surface to be modified, which is important in the process of integrating the biomaterial with the body. In addition, increasing hydrophilicity the adhesion of bacteria to the implant surface is reduced. As a result, this diminishes the risk of infection in the implantation stage. Siloxane surfactants are compounds that can be used to modify the hydrophilicity of the surface of Ti-6Al-4V (ELI) alloy. Siloxane surfactants are a group of surface-active compounds containing a methylene siloxane moiety. These compounds are completely neutral to the human body, and at the same time exhibit antibacterial and bacteriostatic properties. Owing their solubility in water, the presence of their adsorption layers on a given surface reduces the bacteria growth before the biomaterial implantation. Thus the aim of the study was to determine the hydrophilic-hydrophobic properties of Ti-6Al-4V (ELI) surface and their changes as a result of silicone surfactants layers formed from the aqueous solutions with different surfactant concentrations. For this purpose the components and parameters of Ti-6Al-4V (ELI) surface as well as Ti-6Al-4V (ELI) surface/surfactant layer surface tensions were calculated using the measured contact angle of model liquids values and van Oss et al. approaches to the interfacial tensions.

2-8

# Green chemistry unveiled: chitin and chitosan from organic mushroom waste for biomedical applications

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The extraction of biopolymers using natural deep eutectic solvents (NADES) offers a promising approach for developing sustainable and biocompatible materials for biomedical applications. In this study, we investigated the extraction of both chitin and chitosan from organic *Agaricus bisporus* mushrooms using NADES, a method known for its sustainability and environmental friendliness. The structural and physicochemical properties were evaluated in detail by various characterization techniques, such as X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), thermogravimetric (DTG/TGA) analysis, scanning electron microscopy (SEM), atomic force microscopy (AFM), and nuclear magnetic resonance (1H NMR) techniques. By optimizing the NADES extraction conditions, high-purity chitin and chitosan were achieved, surpassing the purity levels achieved by traditional (acid/alkali) chemical methods. Additionally, NADES-extracted chitosan exhibited an impressive degree of deacetylation (DD%) and a remarkable crystallinity index (CrI) of up to 61.77%, highlighting its enhanced functionality for biomedical applications. Importantly, the mushroom-derived biopolymers exhibited no cytotoxicity after 24 and 72h, particularly at a low concentration of 0.625 mg/mL against both *Escherichia coli* (*E. coli*) and *Staphylococcus aureus* (*S. Aureus*). NADES-derived chitosan shows relatively higher antioxidant activity, especially at low concentrations (≤ 0.625 mg/mL). Interestingly, NADES-extracted chitosan exhibited a rapid biodegradation rate, making it a promising candidate for wound healing and other antibacterial applications. As a result, NADES-extracted chitosan from organic *Agaricus bisporus* mushrooms is a valid alternative to commercial chitosan for antibacterial and biomedical uses.

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3-1

# Effect of catalyst loading on visible-light degradation of Acid Orange 7 by microwave-synthesized $BiVO_4$ nanoparticles

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Azo dyes are among the most persistent classes of industrial pollutants, frequently resisting conventional treatment and motivating visible-light advanced oxidation approaches. This study investigates the degradation of Acid Orange 7 (AO7) using bismuth vanadate ($BiVO_4$) nanoparticles synthesized via a rapid, energy-efficient microwave-assisted method (~98% yield). X-ray diffraction (XRD) confirmed a phase-pure monoclinic scheelite structure with an average crystallite size of ~19 nm, while transmission electron microscopy (TEM) showed uniform, near-spherical particles with minimal agglomeration. UV–Vis diffuse reflectance combined with Tauc's analysis (Kubelka–Munk transform, direct transition, $n = 1/2$) gave a band gap of 2.55 eV, consistent with visible-light activity of $BiVO_4$. Photocatalytic experiments on 20 ppm AO7 (50 mL) were performed under a 300 W xenon light source at the native pH (4.5). Suspensions (10–20 mg $BiVO_4$) were ultrasonicated for 15 min and equilibrated in the dark for 60 min; decolorization at 484 nm was monitored for 120 min. Increasing the catalyst mass from 10 to 15 mg raised AO7 removal to 77% at 120 min, whereas 20 mg provided only a marginal additional gain. Kinetics followed a pseudo-first-order model ($R^2 = 0.996$). The loading dependence reflects a balance between added active surface and light shielding/aggregation at higher solids. Under these conditions, ~15 mg per 50 mL is a practical loading for efficient visible-light-driven decolorization with pristine $BiVO_4$.

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3-2

# Functional properties of novel self-cleaning materials: multi-analytical in situ and laboratory approach

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The degradation and aging of building materials pose significant challenges in the maintenance of contemporary architecture. An effective approach to mitigating these processes lies in active surface protection through self-cleaning materials that exploit natural photocatalytic phenomena. Such materials provide preventive, long-lasting defense against various environmental contaminants. This study presents the development, laboratory testing, and large-scale application of a novel photocatalytic suspension formulated in laboratory conditions, after which scale-up to industrial production was executed. The research included both controlled laboratory experiments and in situ investigations of developed photocatalytic suspension applied to diverse façade materials, including mortars, renders, bricks, colored layers, and façade paints. To ensure high compatibility with mineral substrates, laboratory models were designed based on the detailed characterization of real-world systems. Following laboratory verification of compatibility and efficiency, the photocatalytic suspension was tested on several case study sites. Comprehensive analyses including comparative chemical-mineralogical, textural, microstructural, microbiological, photocatalytic, durability, and colorimetric tests were performed before and after treatment with the $TiO_2$–layered double hydroxide (LDH) based coating. The findings confirmed strong compatibility of suspension with all investigated façade materials. Long-term monitoring over 10 years period demonstrated that the developed suspension is a stable and effective protective system, capable of providing sustained resistance to environmental contaminants on building surfaces.

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3-3

# Ion exchange membranes for selective separation of metal ions from waste battery solutions

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Ion-exchange membranes selectively permit specific ions to pass while blocking others. Reverse electrodialysis (RED) exploits ion concentration gradients to spontaneously generate energy by simulating cathodic conditions. We investigated two membrane configurations anion and cation exchange membranes (AEM-CEM) and bipolar with cation exchange membranes (BP-CEM) to examine how membrane type, functional properties, and ion valency influence ion transport efficiency and selectivity. The membranes were characterized using ATR-FTIR and XPS to identify functional groups and determine elemental composition, and SEM to observe surface morphology. Because RED performance depends strongly on water-membrane interactions, contact angles were measured to assess hydrophilicity. Metal ion concentrations were quantified using ICP-OES and NMR spectroscopy. Our analyses confirmed the presence of sulfonic and carboxylic functional groups on the membrane surfaces. Contact angles below 90° indicated hydrophilic behavior, and SEM images revealed a slightly wavy, smooth, non-porous morphology favorable for ion transport. Using 1 M $Li_2SO_4$ as the high-concentration (HC) solution and various low-concentration (LC) solutions, we achieved up to 80% lithium transport when $Li_2SO_4$ served as the LC solution. Comparable lithium transport was obtained with Milli-Q water as the LC solution, but with reduced lithium leakage. In the BP-CEM system, lithium transport efficiency was similar. For mixed $Li_2SO_4$-$CoSO_4$ HC solutions, $Co^{2+}$ migrated faster than $Li^+$; however, the addition of EDTA suppressed $Co^{2+}$ migration and enhanced $Li^+$ transport (56%). Our study demonstrates that membrane functional groups, surface morphology, and hydrophilicity play crucial roles in determining selective ion transport in RED systems. Divalent ions exhibit faster migration due to stronger interactions with sulfonic and carboxylic groups, while EDTA complexation improves lithium selectivity. Comparison of AEM-CEM and BP-CEM configurations indicates that BP-CEM provides more controlled lithium transport by restricting cation movement and minimizing undesired anion crossover. These findings highlight the potential of ion-exchange membrane-based RED for efficient, selective, and sustainable lithium recovery from spent cathode materials.

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3-4

# Evaluation of silicone sheets and silicone foam as biomimetic materials for passive sampling of hydrophobic organic compounds in water

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Water pollution from urbanization, industrialization, and agriculture, amongst others, releases diverse hydrophobic organic compounds (HOCs), some of which are prone to bioaccumulation. In aquatic environments, conventional grab water sampling methods often fail to capture the bioavailable concentrations of HOCs, which are directly linked to their potential for bioaccumulation. This issue requires detailed study and continuous monitoring, emphasizing the importance of high-capacity, biomimetic sampling materials. Equilibrium passive sampling with silicone polymers offers an alternative approach, mimicking the passive diffusion processes that govern chemical uptake in biota, while providing more accurate and realistic estimates of the freely dissolved and thus potentially bioavailable fractions of contaminants. However, reaching equilibrium partitioning between HOCs and silicone polymers within practical exposure times is challenging, as it may take several months to years, due to slow diffusion and resistance across the water boundary layer. To address these limitations, well-established silicone sheets and a novel silicone foam were evaluated and compared as materials for passive sampling of HOCs in water. In order to increase the uptake rate, an active water flow was applied, reducing the boundary layer thickness and accelerating mass transfer. With this approach, (a) thin layers of silicone polymer were tested, and (b) a novel silicone foam with a larger surface area was evaluated and compared to conventional silicone sheets to assess performance in achieving equilibrium. Silicone sheets (250 μm) and silicone foam (2 mm) were deployed in parallel under identical dynamic conditions to assess uptake kinetics and equilibrium attainment. In this study, the equilibrium was reached for compounds with $\log K_{\mathrm{ow}}$ up to 5.9 over 14 days, with comparable $t_{95}$ values for both materials despite the foam's nominally larger thickness, likely due to its porous structure reducing the effective diffusion path. Additional experiments with performance reference compound (PRC)-spiked silicone sheets and foam, deployed for 31 days in a wastewater treatment plant, confirmed that equilibrium was reached for compounds with $\log K_{\mathrm{ow}} < 5.5$. Sampling rates were broadly similar, although model fitting for the foam was less precise, likely due to the greater accumulation of biofouling. These results support the assumption that material properties, including structure, thickness, and surface area, affect sampling efficiency, and no enhanced uptake was observed for the foam, despite the higher surface/mass ratio. Overall, silicone sheets and foam performed comparably, with sheets currently preferred for ease of handling, cleaning and consistent performance, while the foam offers a promising, novel design for future passive equilibrium sampling applications.

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3-5

# A green and rapid dispersive liquid–liquid microextraction of $^{137}$Cs using deep eutectic solvents

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$^{137}$Cs is one of the fission products of $^{235}$U, often linked to nuclear weapons production. Due to its relatively long half-life of 30.2 years, this anthropogenic radionuclide is routinely monitored in environmental samples as an indicator of radioactive contamination. Since $^{137}$Cs occurs in very low concentrations in the environment, preconcentration is required prior to measurement. Conventional sample preparation is typically time-consuming and involve multiple steps, often including hazardous reagents. In recent decades, there has been growing interest in “green” extraction methods that employ safer and more sustainable chemicals. Liquid–liquid extraction remains one of the most common separation and preconcentration techniques. Recently, deep eutectic solvents (DESs) have emerged as promising green alternatives because of their ease of preparation, low cost and toxicity, and biodegradability. They are increasingly used for the extraction of organic compounds and, more recently, metal ions. Nevertheless, their application in radioanalytical studies remains scarce, and to date, no reports exist on their potential for radioactive cesium extraction. The present study aimes to develop a fast and reliable method for determining $^{137}$Cs in water using gamma spectrometry and for that proposes a simple and environmentally friendly analytical procedure based on dispersive liquid–liquid microextraction (DLLME) with DESs prepared from lauric acid, thymol, and camphor, along with bis(2-ethylhexyl) hydrogen phosphate (DEHPA) and 18-crown-6 ether as additives. Two different ratios between the precursors of the DES mixture were tested to find how they affect the extraction efficiency of $^{137}$Cs, and the presence of the two additives in various concentrations. The dependence of the pH of the model solution of the radionuclide, the contact time and the ratio between the two phases was also studied. After the optimization of the extraction conditions, the procedure was applied to three real water samples, contaminated in advance with $^{137}$Cs. The excellent recoveries obtained confirm the applicability of the proposed procedure. The AGREE and ComplexMoGAPI metric tools were used to evaluate the greenness of the method.

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3-6

# Synthesis and characterization of bioplastics based on corn starch as a sustainable material

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Corn starch, as a natural and biodegradable polysaccharide, is increasingly used as a basic raw material in the development of sustainable materials, especially bioplastics. Due to its wide availability, low cost, non-toxicity and ability to form films in the presence of plasticisers, it is an extremely suitable choice for the production of biodegradable polymeric materials. In this study, the possibility of bioplastic synthesis based on corn starch was examined. Bioplastics were obtained from starch powder, previously isolated from corn, with the addition of glycerin as a plasticiser, tartaric acid as a crosslinking agent and water. The synthesised biopolymer shows suitable homogeneity, flexibility and stability. Characterisation of the obtained biomaterial included optical microscopy, which analysed the surface morphology, as well as FTIR analysis, which confirmed the presence of functional groups characteristic of the polysaccharide matrix, thus confirming the successful synthesis of bioplastics. The thermal characteristics of corn starch-based biopolymers were investigated using the DSC method. In this way, the synthesis of bioplastics based on corn starch contributes to the development of sustainable and environmentally friendly solutions in various industrial branches (pharmaceutical, cosmetic, food, textile, etc.), reducing the negative impact of synthetic plastic waste on the environment. Future studies will focus on evaluating properties of synthesised bioplastics depending on the ratio of components, drying conditions and mechanical characteristics.

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3-7

# Investigation on the ferroelectric and photocatalytic properties of lead-free high entropy oxide

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Recently, ferroelectric high entropy oxides (FHEOs) have grabbed the attention of the scientific community due to the simultaneous existence of configurational entropy and internal polarisation. In this work, we have prepared lead-free $(Ba_{0.2}Bi_{0.2}Sr_{0.2}Na_{0.2}Ca_{0.2})TiO_3$ high-entropy oxide (HEO) pellets via the traditional solid-state synthesis method for photocatalytic applications. The thermal analysis of the balled milled powder confirmed the overall completion of carbonate decomposition and crystallisation processes at around 850 $^0$C. The microstructure of the HEO is optimised by varying different synthesis parameters. The optimised sample exhibited the formation of a pseudo-cubic crystal structure, as confirmed by the X-ray diffraction (XRD) and scanning transmission electron microscopy (STEM) analysis. Furthermore, the scanning electron microscopy and energy dispersive X-ray spectroscopy (SEM-EDS) analysis showcased a relatively dense microstructure and uniform distribution of the constituent elements. The slim nature of the polarisation-electric field (P-E) loop, as well as the diffuse, frequency-dependent nature of the dielectric maximum temperature ($T_m$) of the HEO sample, suggested a relaxor ferroelectric behaviour. The optimised HEO pellet demonstrated a photocatalytic efficiency of about 41% in 60 minutes of UV illumination for the degradation of tetracycline antibiotic.

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4-1

# Zn-ZSM5 zeolite oxide coatings with adsorption properties on aluminum

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Metal oxide coatings containing Zn-species are prepared by conventional DC plasma electrolytic oxidation (PEO) of aluminum in water solution of boric acid and borax, with addition of ZSM-5 synthetic zeolite and zinc oxide. In addition, oxide coatings are made in the same supporting electrolyte with addition of solely ZSM-5 or ZnO powder for comparison. Scanning electron microscopy equipped with energy dispersive X-ray spectroscopy and X-ray diffraction measurements are employed to monitor the morphological, structural and chemical changes of obtained oxide coatings. It was found that chemical and phase composition strongly depend on PEO time. Photodegradation and adsorption of methyl orange served as a tool to estimate the potential application of the obtained coatings. The study showed that addition of zeolites can improve adsorption properties of synthesized oxide coatings.

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4-2

# Assessment of mechanical and lechability properties of fly ash-based geopolymers loaded with flotation tailing, aluminum slag and spent grit

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If the best economic and environmental waste management solution is to be achieved in Montenegro in the future, it is important to implement environmentally friendly techniques for processing toxic industrial waste (TIW) of various origins. The objective of this study is to investigate the compressive strength and lechability potential of FA-based geopolymers synthesized for S/S treatment of flotation tailing (FT), aluminum slag (AS), and spent grit (SG) generated during the sandblasting process. The geopolymer synthesis was performed with S/L ratio of 1, using a 10 M solution of NaOH and $Na_2SiO_3$/NaOH mass ratio of 1.5, while the TIW content varied from 1% to 10%. The European Standard EN 12457-2 and TCLP procedure were applied in order to evaluate leachability potential of geopolymer fragments remained after compressive strenght testing. The highest compressive strength was achived for the raw FA-based geopolymer (15.71 MPa), while the values for $FT_{1\text{-}10\%}$ varied from 15.43% to 10.37% and $SG_{1\text{-}10\%}$ from 13.00% to 10.41%. Optimal dosage of aluminium slag was up to 3 %. Further increase of AS addition caused the highly porous and weak structure with an decrease in compressive strenght from 8.39% to 7.85%, respectively. The results of EN 12457-2 indicated that FA-based geopolymers with TIW meet the criteria for waste acceptance in non-hazardous landfills. Similarly, TCLP result of loaded geopolymers confirmed their non-hazardous nature, while content of lead in FT and chromium in SG exceeded regulatory levels, indicating their hazardous nature in raw form.

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4-3

# Gold(III) recovery from aqueous chloride solutions

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Precious metals like gold, palladium, platinum and rhodium have unique chemical and physical properties, which is why they are used in almost every industry field, from jewelry and automotive to medicine. Unfortunately, they are non-renewable resources, and their natural resources are insufficient. At present, we are unable to replace them in many applications. That is why it is so important to recycle precious metals, i.e. recover them from secondary raw materials such as used car exhaust converters or used electrical and electronic equipment. Many recovery methods only allow for the recycling of precious metals from raw materials with a high content of these metals, and also pollute the environment. This creates a need to search for new recovery methods. The use of sorbents impregnated with a new method without the use of toxic organic solvents is a potential alternative. Impregnated sorbents have many advantages, for instance: the reduction of negative impact on the environment, high selectivity towards desired metals and the possibility of recovering metal ions from raw materials with low metal content. The aim of the research was to develop innovative sorbent impregnated using a new method that does not require harmful organic solvents, useful in the selective sorption of Au(III) ions in the presence of Pd(II), Pt(IV) and Rh(III) ions. A hydrophobic copolymer of styrene-divinylbenzene resin was used as a matrix. Tri-n-butyl phosphate was used as an extractant. Impregnation was based on direct mixing of the sorbent with the extractant at elevated temperature without the addition of organic solvents. After impregnation, the sorbent was left to dry at room temperature for 24 hours. The sorbent prepared in this way was used for the sorption of precious metal ions from chloride solutions. 0.2 g of impregnated sorbent was contacted with 50 mL of a solution containing 10 ppm of each of the precious metals: Au(III), Pd(II), Pt(IV) and Rh(III) at different concentrations of hydrochloric acid. Samples were taken after appropriate time: 1, 5, 15, 30, 60, 120, 240, 360 and 1440 minutes, and was determined by inductively coupled plasma–optical emission spectrometry (ICP-OES). Based on the results, it was demonstrated that the prepared sorbent is exceptionally selective towards Au(III) ions, while Pd(II), Pt(IV) and Rh(III) ions remain in the solution. To verify the practical applicability of the sorbent, it was used to sorb Au(III) ions from a solution obtained after leaching waste electrical and electronic equipment. A high recovery percentage of Au(III) ions was achieved despite the presence of large amounts of interfering ions such as copper, nickel and iron.

4-4

# Characterization and potential reuse of dust generated during pp and abs plastic recycling

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This research investigates the potential for reusing dust generated during the recycling of polypropylene (PP) and acrylonitrile-butadiene-styrene (ABS) plastics. The PP and ABS materials, sourced from recycled washing machines and processed into flakes approximately 2–5 cm in size, were ground and separated using an infrared (IR) plastic separator. Dust samples collected from the dust removal system of the separation machine were then prepared for analysis. These samples were characterized using several analytical techniques, including ATR-FTIR (for polymer identification), XRD (for crystalline phase determination), SEM (for surface morphology), XRF (for elemental composition), and optical microscopy (for particle size analysis). The aim of this study is to determine the physicochemical properties of the dust and assess its potential for future applications.

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4-5

# Flotation-based separation and recycling of materials from cooling

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This work concerns the separation of HIPS (High Impact Polystyrene) from ABS (Acrylonitrile–Butadiene–Styrene) using a flotation tank with tap water, NaCl, and SLES (sodium lauryl ether sulfate). The polymers, in the form of flakes, were identified based on their FTIR spectra and subsequently examined for contact angle measurements using the sessile drop method. In addition, the effect of nonionic surfactants—specifically ethoxylated alcohols—on the sedimentation rate of calcium carbonate suspension in tap water was studied. Such a suspension with added surfactant was also used for flotation purposes. The plastics flakes separated by flotation were then subjected to further analyses, including density measurements, XRD, and surface characterization (SEM). Moreover, HIPS flakes were processed using a laboratory injection molding machine, both with and without the addition of colorants. The resulting HIPS products (injection-molded paddles) were tested for their mechanical, rheological, surface, and optical properties. Additionally, studies were conducted on the HIPS material degradation, indicating that surface yellowing (aging/degradation) affects the final color of the molded parts. The degradation of the polymer was confirmed by a decrease in ATR-FTIR absorbance, which corresponded to changes in mechanical and rheological properties as well as alterations in surface characteristics.

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4-6

# Smoke emission studies on glass/polyester laminates modified with bio-based flame retardant

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The main disadvantage of composites is the flammability of their organic matrix, which limits their use in applications where a high fire safety level is necessary. Compliance with flammability requirements is possible through the use of flame retardants, which may increase smoke emission, hindering evacuation and reducing safety in fire condi-tions. The aim of the study is to analyze the smoke emission parameters of glass/polyester laminates modified with arginine phosphate (ArgPA) – a novel bio-based flame retardant, by cumulative and dynamic type methods. The smoke density was assessed by the smoke density chamber tests according to ISO 5659-2, and the smoke emission parameters were established with the cone calorimeter tests according to ISO 5660-1. In flameless condi-tions, the ArgPA increases the specific optical density of smoke (Ds) in the initial period of measurement (until 755 s) compared to laminate Z0. However, significant changes were observed when the ignition of samples occurred. For the ArgPA modified laminate, the maximum value of Ds was achieved over a significantly longer period (by 15 %), and the total smoke release was reduced by 7.5 % compared to Z0 laminate. Smoke toxicity studies revealed the decrease of toxic CO emitted during combustion compared to the non-modified resin. The obtained results suggest that the ArgPA can both reduce flam-mability and smoke emission of glass/polyester laminates.

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5-1

# Investigation of quantitative damage and impurity depth profiles in the case of MgO crystals using the EBS/C technique

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Magnesium oxide possesses exceptional physical and chemical properties which makes it suitable material for applications in harsh environments such as nuclear technologies and space. Due to exposure to ionizing radiation, defects are formed within the material. Therefore, it is important to understand the mechanism of the radiation damage occurrence in order to utilize it appropriately. In this study, material damage produced under such conditions was simulated using the ion implantation method. The determination of quantitative damage and impurity depth profiles were demonstrated on the sample of magnesium oxide single crystal by Elastic Backscattering Spectrometry (EBS/C). The results of the EBS/C were analyzed with the new ChannelingSIMulation (CSIM) computer code. As the main output, quantitative damage depth profiles were obtained. Additionaly, the permanent problems in conventional EBS analyses involve determination of impurities depth profiles. This is especially challenging in cases where the impurity elements are lighter than the matrix elements, and their concentrations are low. The application of the CSIM code for EBS/C spectra analysis revealed the possibility to determine the quantitative profile of impurities in a material with matrix elements that are heavier than the impurity elements.

5-2

# Interface-engineered STO thin films on silicon photocathodes for photoelectrochemical hydrogen evolution reaction

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Epitaxial strontium titanate (STO) thin films were deposited by pulsed laser deposition onto bare and reduced graphene oxide (rGO)-buffered silicon (Si) substrates to explore their potential as protective and functional coatings for Si photocathodes in photoelectrochemical (PEC) hydrogen evolution reaction. Depositions were carried out at 515 ℃ and 700 ℃, and the resulting films were characterized using reflection high energy electron diffraction (RHEED), atomic force microscopy (AFM), scanning electron microscopy (SEM), X-ray diffraction (XRD), X-ray reflectivity (XRR), and X-ray photoelectron spectroscopy (XPS). AFM and XRR analyses revealed that the STO films grown on rGO-buffered Si exhibited smoother surfaces and lower roughness compared to those grown directly on Si. XRD and RHEED methods revealed that the growth at 700 °C led to the formation of textured film, while deposition at 515 ℃ on rGO-buffered Si substrate produced highly crystalline STO film with a dominant (002) out-of-plane orientation. The sharp RHEED streaks further confirmed its high crystallinity and smoothness. Electrochemical measurments showed that epitaxial STO/rGO photocathodes achieved significantly improved PEC performance, featuring a reduced onset potential (0.24 V vs RHE), higher photocurrent density ($-27.78$ mA $cm^{-2}$), and greater long-term stability. Conversely, non-epitaxial samples containing interfacial silicate or silicide layers, particularly those deposited at 700 °C, exhibited lower activity and reduced stability, as confirmed by electrochemical impendance spectroscopy (EIS). The results highlight the crucial role of interface engineering and deposition temperature in tailoring the structural and functional performance of oxide/Si heterostructures for efficient hydrogen evolution reaction.

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5-3

# Reference electrode design and understanding magnesium surface passivation in magnesium-sulfur batteries

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Magnesium based batteries are gaining attention as candidates for post lithium-ion energy storage landscape, because magnesium is earth abundant, has a high volumetric capacity and can pair with sulfur to enable high-energy Mg-S systems. Progress in this field has been slowed by limited understanding of magnesium electrochemistry. One of the central challenges lies in the lack of reliable reference electrodes, which makes it difficult to separate true electrode behavior from drifting potentials in complex electrolytes. This work introduces two magnesium reference electrode designs, one compatible with $Mg(TFSI)_2$ electrolytes, and another for mixed $Mg(TFSI)_2$-$MgCl_2$ systems. These electrodes enable accurate and reproducible measurements of Mg plating and stripping. After establishing reference performance, we use them to probe how the presence of sulfur affects magnesium deposition and stripping behavior in each electrolyte. Glassy carbon substrates were selected to avoid interference from native Mg surface films, and to allow clearer interpretation of interfacial reactions. Deposited films were examined using *ex situ* X-ray photoelectron spectroscopy and scanning electron microscopy to reveal chemical species and morphological changes associated with passivation. The combined results give a clearer picture of Mg surface passivation mechanisms in Mg-S environments and support the development of reliable diagnostic tools for emerging magnesium battery chemistries.

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5-4

# Probing failure mechanisms in solid-state lithium batteries using an integrated micro-reference electrode

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All-solid-state lithium-metal batteries are a promising technology for achieving high performance and energy density, enabled by the high theoretical gravimetric capacity of lithium metal anodes (3860 mAhg$^{-1}$). Although solid-state electrolytes are considered a solution for suppressing lithium dendrite growth due to their mechanical rigidity, dendrites still form, representing a critical limitation for integrating lithium metal with solid electrolytes. Here, we report an approach to probe failure mechanisms in symmetric lithium cells by integrating a gold micro-reference electrode into a sulfide solid electrolyte ($Li_7P_3S_{11}$). Using operando impedance spectroscopy in a three-electrode symmetric cell setup, we distinguish two failure mechanisms: i) lithium dendrite growth on the plated lithium electrode leading to cell short-circuit, and ii) contact loss during prolonged lithium stripping, resulting in a gradual increase in interfacial resistance. Scanning electron microscopy revealed delamination of the stripped lithium layer from the solid-electrolyte pellet. We propose that preferential lithium stripping through the grain boundaries of the lithium anode, rather than surface stripping at the lithium-electrolyte interface, drives this contact loss.

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# Insights into the operation of microporous carbon hosts in lithium-sulfur batteries

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The global shift toward sustainable energy production demands advanced energy storage solutions with increase energy density. Lithium-sulfur (Li-S) batteries represent a promising candidate thanks to sulfur's high theoretical capacity (1675 $mAhg^{-1}$), abundance, and low cost. However, challenges such as the dissolution of polysulfides in ether-based electrolytes and reactivity with carbonate-based electrolytes have long hindered their commercialization. A strategy to avoid these limitations is the use of a microporous carbon host, confining sulfur inside the micropores and limiting its reactivity with the solvent molecules. This study explores the electrochemical mechanism of this class of cathode materials, following the evolution of the impedance throughout its operation. By employing an *in situ* lithiated gold micro-reference electrode, it is possible to record three electrode electrochemical impedance spectroscopy (EIS) and selectively measure the impedance of the cathode during the operation of the cell. OCV and *Operando* EIS reveal the evolution of two main features in the spectra of the composite cathode. The first feature exhibits a capacitance consistent with the expected geometrical contact surface area between the active particles and the current collector. A dedicated experimental investigation allows to attribute this feature to contact resistance. The evolution of the second feature in the model experiments suggests that different concurring physicochemical phenomena (such as charge transfer and cathode-electrolyte interface formation) may contribute to its shape and magnitude. To validate this hypothesis, multiple experiments are used to investigate the effects of particle surface area and electrolyte salt concentration. These results will clarify the origin of the internal resistance and associated overpotentials in these systems, and guide future optimization of this class of cathode materials.

5-6

# Activity and stability analysis of Pt-Co nanoalloy fuel cell electrocatalyst supported on a hybrid $TiON_x$/GO substrate

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Large-scale commercial viability of Proton Exchange Membrane Fuel Cell (PEMFC) technology as an eco-friendly substitution for internal combustion engines relies on several critical factors. One of them is the cost of production, which heavily depends on the quantity of Pt used in the PEMFC catalyst, especially for the inhibited cathodic reaction (oxygen reduction). Another is the long-term stability and retention of performance in operational conditions. A variety of different approaches have been developed to improve the electrocatalyst in these regards, of which alloying and dispersion on stable and conductive supporting materials are the most common. In this work, the activity of the in-house designed $TiON_x$/rGO supported Pt-Co nanoalloy electrocatalysts was studied using the standard rotating disk electrode (RDE) setup for low current density characterisation and gas diffusion electrode (GDE) setup for high current densities. Stability of the catalyst was analysed by combining two advanced, previously established, but now upgraded methods: high-temperature disc electrode (HT-DE) methodology and identical location transmission electron microscopy (IL-TEM). HT-DE was used for accelerated degradation tests (ADTs), consisting of 10,000 trapezoidal wave cycles (0.6 (3 s) – 0.95 (3 s) V) performed in a liquid electrolyte half-cell at the temperature which simulates close-to-real operational conditions (60 °C). IL-TEM was used for the observation of the same electrocatalyst nanoparticles before and after ADT. This allows for the monitoring of the exact degradation history of the observed particles, leading to a deep, fundamental understanding of the structure-stability relationship. The focus of this work is on the characterisation of intrinsic electrochemical properties and the significance of nanoscale structural changes induced by ADTs. Our findings highlight potential benefits of using TiONx/rGO hybrid support, as opposed to carbon black materials.

5-7

## Search for a storage phosphor based on YAP for emerging applcations

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Accumulative phosphors are usually used in luminescent dosimetry of ionizing radiation, but one of the main requirements for them is the so-called tissue equivalence, which is determined by the proximity of the effective atomic number $Z_{eff}$ of their composition to the living tissue of the human body ($Z_{eff} \approx 7.5$). The tissue equivalence of dosimetric phosphor ensures approximately the same course of all processes of interaction of radiation with matter and, accordingly, the proximity of the dose absorbed in the body and dosimetric material, regardless of the energy of radiation. For this reason, phosphors with high $Z_{eff}$ values have been studied much less. On the other hand, it is precisely the significantly more intense absorption of radiation energy in the energy range where the photoelectric effect dominates that creates new opportunities for the use of phosphors with high $Z_{eff}$ values – in X-ray imaging, and estimation of the radiation spectrum by the difference in the measured values of the absorbed dose. The latter task is important from the point of view of determining the quality of X-ray sources in medical diagnostics and therapy as well as for rapid recognition of an unknown radioactive source in the context of radiation terrorist attacks. In this work, we report the results of the study of X-ray, photoluminescence, phosphorescence, and optically stimulated luminescence (OSL) of two materials based on yttrium-aluminum perovskite (YAP) $YAlO_3$, activated by Mn and Bi ions. The first one was firstly studied for termoluminescence dosimetry and demonstrated its advantages determined by matrix properties. But attempts to use it by means of OSL method, which is much more advanced method of dosimetry today revealed that this material is much more preferable for applications as material for persistent luminescence. Instead, YAP:Bi proved to be much more suitable for OSL dosimetry, while retaining all the previously identified advantages of the YAP matrix .

6-1

# Electrodeposited Co-Sn alloys on Ni mesh as efficient cathodes for alkaline water electrolysis

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The rising global demand for electricity, depletion of fossil resources, and growing environmental concerns have intensified efforts to reduce greenhouse gas emissions by mid-century. Hydrogen obtained through water electrolysis powered by renewables represents a viable route towards sustainable and carbon-free energy systems. Among the available technologies, alkaline water electrolysis (AWE) is particularly attractive due to its maturity, scalability, and reliance on earth-abundant materials. However, the development of efficient, durable, and low-cost cathodes remains a key challenge for successful widespread of AWE and to achieve hydrogen costs comparable to those from conventional methods (steam methane reforming, and coal gasification). Building on our previous work on electrodeposition of Ni-Sn coatings on 3D porous Ni substrates for hydrogen evolution reaction (HER) in zero-gap electrolyzers, this study extends the electrodeposition approach to Co-Sn alloys on Ni mesh substrates, which are widely used in industrial AWE systems. The Co-Sn/Ni mesh cathodes were prepared by galvanostatic electrodeposition from glycine-pyrophosphate bath. Bath composition and deposition current density were varied to optimize coating composition and microstructure. Electrochemical measurements in 1 M KOH revealed strong coating adhesion and stability, with no performance degradation even at high HER current densities. The Co-Sn coatings achieved a significant reduction in HER overpotential compared to both bare and Co-coated Ni mesh. Furthermore, testing in a zero-gap flow electrolyzer (30 wt.% KOH, 70 °C) demonstrated a cell voltage reduction of approx. 200 mV at 500 mA $cm^{-2}$ compared to a cell using bare Ni mesh cathode.

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6-2

# Infrared thermography as a tool for assessment of thermal effects of RDX-based cast-cured thermobaric composite explosives

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This study reports on the preparation and field evaluation of thermal effects of selected formulations of thermobaric solid cast-cured polymer-bonded explosives (PBX) using infrared (IR) thermography. The composite explosives were manufactured as monolithic charges with the aim of promoting condensed-phase combustion and extended thermal output characteristic of thermobaric behavior. Three different formulations were prepared in laboratory batches, based on cyclotrimethylenetrinitramine(RDX), ammonium perchlorate (AP), aluminium powder (Al), and a polymer binder: hydroxyl-terminated polybutadiene (HTPB) cured with isophoronediisocyanate (IPDI). As a reference, pure trinitrotoluene (TNT) charge was used. All the specimens were in cylindrical shape, 50 mm in diameter, and had a mass of 1 kg. For each composite formulations, three charges were produced. Controlled field trials were carried out to assess real-conditions performance, in static conditions. The tests included charge initiation with simultaneous high-speed video and IR thermal imaging.Infrared thermography provided time-temperature profiles that were analyzed to quantify thermal emission, spatial distribution of hot zones, and the temporal evolution of post-detonation thermal emission. Particular attention was paid to repeatability of thermal signatures for replicate charges. High-speed imaging was used to estimate the size of the evolved post-detonation fire-balls. Results demonstrate that the cast-cured PBX composites generated persistent thermal fields extending well beyond the primary shock event, with clear differences in time profiles of post-detonation cooling when compared to conventional TNT charges used as reference. The use of IR thermography proved effective for capturing the thermal component of thermobaric performance under realistic conditions. The obtained results may have further applications in new energetic materials design, performance assessment, and safety testing procedures.

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6-3

# Impact of accelerated aging under variable conditions on thermobaric PBX: a vacuum stability test study

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The characterization of final products containing energetic materials is of crucial importance for ensuring safety during production, handling, and long-term storage. Although cast-cured PBX formulations generally demonstrate considerable resistance to degradation, a enhanced understanding of their aging behavior is essential to prevent potential accidents and to ensure reliability in service. This study investigates the influence of accelerated aging on the stability of cast-cured PBX, of a selected thermobaric formulation, and examines the role of different climatic conditions in the degradation process by using Vacuum Stability Test (VST) tehnique, which was selected as the method of choice owing to its reliability, safety, rapid execution, and cost-effectiveness at the laboratory scale. A formulation based on HTPB/Al/AP/HMX was produced in industrial conditions. The samples were taken from three batches and conditioned in a climate chamber and in a salt-mist chamber to simulate continental and Mediterranean storage environments. Both production and surveillance samples were evaluated using the (VST), in accordance with STANAG 4556. Samples were exposed to elevated temperature and humidity and subsequently tested for 40 hours at 100 °C to monitor the volume of decomposition gases released during the VST. The results revealed an increase in gas evolution following exposure to extreme conditioning; however, all measured values remained within the prescribed safety limits. These findings provide valuable insights into into the degradation extent of thermobaric PBX formulations and confirm the relevance of vacuum stability testing as a powerful screening tool for assessing chemical and thermal stability under diverse environmental factors.

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6-4

# Monitoring stabilizer consumption in nitrocellulose-based propellants under accelerated aging conditions

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Nitrocellulose-based propellants (single, double, and triple-base powder as well as rocket propellants) undergo slow, continuous chemical changes over time, which in rare cases can result in self-ignition. While such reactions cannot be entirely avoided, the inclusion of small quantities of stabilizers significantly prolongs the safe storage and handling life of these energetic materials. Most often, stabilizers based on urea derivatives, as Centralite I and II, are included in formulations thereof. In this study, the chemical stability of propellant samples was investigated using a accelerated aging and periodic monitoring of stabilizer content. Samples prepared according to the domestic standard were conditioned in chamber for 48 hours and then maintained in thermo blocks at 343 K. In defined intervals samples were extracted and analyzed by high-performance liquid chromatography (HPLC) to quantify the residual stabilizer content, providing a temporal profile of stabilizer consumption under controlled aging conditions. Results show that the use of urea-based stabilizers, specifically Centralite I, effectively preserved the chemical stability of all tested samples throughout the experiment. Even under accelerated aging, stabilizer reduction remained within safe limits, ensuring reliable long-term performance. These findings demonstrate that systematic monitoring of stabilizer retention under controlled aging is a reliable approach for evaluating the chemical stability of nitrocellulose-based propellants, offering valuable insight for optimizing storage strategies and minimizing potential hazards associated with energetic materials.

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6-5

# Sandwich composites reinforced with IF-$WS_2$ nanoparticles and graphene for EMS shielding

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Novel multifunctional sandwich composite structures for potential applications in electromagnetic shielding (EMS) have been designed and characterized within this study. The material concept includes carbon fabric facing sheets, with a light-weight core in the form of aramid honeycomb, all impregnated with epoxy resin as adhesive. The adhesive was used with or without addition of functional nanostructures: inorganic fullerene-like tungsten disulfide, IF-$WS_2$ nanoparticles, and graphene nanoplatelets. The IF-$WS_2$ nanoparticles and graphene were selected for their high electromagnetic attenuation, mechanical resistance, and lightweight properties. These nanostructures were incorporated in the impregnating adhesive matrix, to improve electromagnetic, mechanical, and spectrophotometric properties of the composite. The influence of these nanostructures on mechanical performance was evaluated through compression and impact tests, while EMS shielding efficiency and spectrophotometric behavior were investigated across relevant spectral ranges. The obtained results confirmed that the inclusion of IF-$WS_2$ nanoparticles and graphene enhances EMS shielding, contributes to multispectral camouflage, and improves compression strength. These findings demonstrate the potential of polymer–nanoparticle hybrid systems as lightweight, multifunctional materials suitable for advanced defense and protective applications.

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6-6

# Oxidation resistance and mechanical properties of hafnium carbonitride ceramics

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In modern materials science, one of the main tasks is to obtain new materials with outstanding properties that can operate under extreme conditions, such as exposure to high temperatures, aggressive chemical environments, intense oxidative stress, mechanical loads, etc. Research into ceramic materials plays a significant role in solving this problem. Thus, using the molecular dynamics method, it was discovered that a ceramic material based on hafnium carbonitride will have the highest melting point among all known compounds of about 4200 °C, which makes it a promising object for further research. Also, for these compounds significant mechanical properties of materials depending on stoichiometry were observed. Thus, by changing the stoichiometry, it becomes possible to change the properties of materials based on hafnium carbonitride, achieving the previously predicted high melting points and obtaining significant mechanical properties. In the work carried out, ceramic samples based on hafnium carbonitride were obtained by sintering hafnium carbide and nitride powders using hot pressing and spark plasma sintering. For sintering, ceramic powders of hafnium carbide and nitride with a particle size of less than 40 μm were prepared, mixed wet. The prepared mixtures were sintered at a temperature of 2000. The true density of the studied materials was determined according to the additivity rule. The apparent density of the samples was determined by hydrostatic weighing. Based on the data obtained, their porosity was determined. The sintered samples were prepared for testing on the NanoIndenter G 200 device. The indentation hardness and Young's moduli of the samples were tested on this device. These properties are determined by analyzing the loading curve constructed during the tests. It was found that hot pressing results in lower porosity of the samples compared to the sample obtained by spark plasma sintering, which is due to the specific features of the sintering processes. Thus, spark plasma sintering provides the ability to quickly obtain bulk samples due to the high heating rate of about 100 °C per minute, while during hot pressing the heating rate is 5 °C per minute. Due to the longer sintering time during hot pressing, the diffusion processes corresponding to the formation of a solid solution of hafnium carbonitride occur more completely, which accordingly affects the reduced porosity of the material. During oxidation tests it was found that the oxidation resistance of the samples increases with increasing N/(C+N) ratio. During oxidation, a dense protective oxide film based on the cubic modification of hafnium dioxide is formed. It was found that the oxide is stabilized by introducing nitrogen and carbon atoms that form an oxycarbonitride phase. The mechanical properties of the studied samples increase significantly with the formation of hafnium carbonitride compared to samples based on hafnium carbide and nitride. It was found that with an increase in the carbon content in the studied materials, its hardness and Young's modulus increase, while the crack resistance of the materials, on the contrary, increases with an increase in the nitrogen content in the studied materials. The strength of the studied materials also increases with increasing nitrogen content.

7-1

# Raman signatures of CDW induced phonon folding in $TaTe_4$

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$TaTe_4$ is a quasi-one-dimensional transition metal telluride known for its commensurate charge density wave (CDW) state and complex lattice modulation below 450 K. In low-dimensional materials, CDW is mostly driven by strong electron–phonon coupling and give rise to complex lattice distortions and collective electronic order. Despite numerous studies, the detailed crystal structure and vibrational properties associated with the CDW state in $TaTe_4$ have yet to be fully characterized. Using polarization-resolved Raman spectroscopy in the temperature range between 100 and 300 K, we investigated the vibrational properties of $TaTe_4$ within its commensurate CDW phase. In total, seventeen modes were observed, exceeding the ten Raman-active ones expected in the high-temperature phase. The appearance of additional modes indicates zone folding consistent with the $2a \times 2a \times 3c$ CDW superstructure. Comparison with DFT-calculated phonon energies enabled assignment of the original zone-center modes of the high-temperature structure and the additional folded modes activated by the CDW superstructure. Beyond the discrete phonon lines, a broad continuum centered around 150 $cm^{-1}$ was detected and attributed to two-phonon scattering from acoustic branches activated by zone folding. These findings provide direct experimental evidence of phonon folding driven by CDW modulation and underscore the intricate coupling between electronic and lattice degrees of freedom in $TaTe_4$. This study constitutes the first polarization-resolved Raman investigation of $TaTe_4$, offering new insight into the symmetry and temperature evolution of folded phonons in this quasi-low-dimensional CDW system.

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7-2

# Strain-tuned electron–phonon coupling in FeSe

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Iron-based superconductors provide a key platform for studying the interplay between lattice, electronic, and spin degrees of freedom that underlies nematicity and unconventional superconductivity. FeSe, in particular, represents a paradigmatic but highly complex case where nematic, orbital, and spin correlations are strongly coupled, and magnetism remains frustrated. To elucidate how external symmetry-breaking fields influence these coupled degrees of freedom, we examined the effect of uniaxial strain on the lattice dynamics of FeSe using high-resolution Raman scattering. In twinned sample, an additional $A_g$ mode appears very close in energy to the symmetry-allowed $A_{1g}$ phonon in the vicinity of nemato-structural transition, giving rise to an asymmetric line shape. In detwinned sample, this feature becomes more pronounced and its evolution is strongly strain direction-dependent: nematic distortion along ⟨110⟩ slightly narrows, whereas strain along ⟨100⟩ broadens the temperature range of the anomaly. The additional $A_g$ mode most likely arises from enhanced scattering with acoustic phonons along the *M*–*A* direction of the Brillouin zone, consistent with strain-induced modifications of the electron–phonon interaction. Although similar feature has been detected in isostructural and isoelectronic compound FeS, the present results reveal that the microscopic origin of electron–phonon interactions in these materials differs substantially.

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7-3

# Evidence of temperature-induced lifshitz transition in topological material $ZrTe_5$

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Topological Dirac semimetal $ZrTe_5$ has been the subject of extensive experimental and theoretical investigation, as it lies near the boundary between strong and weak topological insulator phases and hosts a Dirac semimetal state at the electronic (Lifshitz) transition. The reported Lifshitz transition temperature in $ZrTe_5$ varies between 50 and 150 K, depending on sample quality and synthesis conditions. In this study, we performed Raman spectroscopic analysis of $ZrTe_5$ single crystals over a temperature range from 40 to 300 K. The measurements were carried out in symmetry-resolved scattering geometries using parallel and cross polarization configurations along the principal crystallographic directions, within the *ac* plane, allowing observation of six $A_g$ and two $B_{2g}$ phonon modes. Our results reveal that all $A_g$ modes exhibit changes in energies and linewidths within the temperature range of the proposed topological transition. In the parallel polarization configuration, peak asymmetry is observed for four of the six $A_g$ modes, while in the crossed polarisation configuration, only the first $B_{2g}$ mode exhibits a similar feature. These asymmetric line shapes are well described by the Fano profile, suggesting a significant electron–phonon interaction. Our Raman scattering results provide insight into the coupling between lattice vibrations and electronic structure and its temperature-driven topological behavior.

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7-4

# Raman study of magnetic transitions in $Mn_3Sn_2$

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Manganese stannide $Mn_3Sn_2$ has recently emerged as a promising material for exploring the interplay between magnetism and topological electronic structure, with its multiple magnetic transitions providing an ideal setting to study spin, lattice, and electronic properties using Raman spectroscopy. The compound crystallizes in the orthorhombic Pnma structure and exhibits multiple magnetic transitions between 180 K and 270 K, along with theoretically predicted nodal lines and nodal surfaces near the Fermi level. In this study, we performed temperature-dependent Raman spectroscopic measurements of $Mn_3Sn_2$ single crystals in the range from 76 K to 300 K using circular polarization configurations to minimize orientation dependence. Several Raman active $A_g$ phonon modes were clearly observed and analyzed as a function of temperature. Pronounced anomalies in phonon energies and linewidths are detected near the antiferromagnetic ordering temperature (~192 K) and two successive ferromagnetic transitions at ~227 K and ~260 K, indicating significant spin-phonon coupling. At lower temperatures, around 80 K, distinct modifications in phonon profiles coincide with the sign reversal of the Seebeck coefficient, suggesting sensitivity of the lattice dynamics to changes in the electronic transport regime. These findings point to a complex but temperature-dependent coupling among the lattice, magnetic, and electronic subsystems in $Mn_3Sn_2$.

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7-5

# Crystal engineering and humidity response of metal halide perovskite $[Ph_3MeP]_2[CuBr_4]$ single crystals: a combined experimental and theoretical approach

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Metal halide perovskites have significantly influenced the scientific community owing to their intriguing applications in photovoltaics and optoelectronics. Metal halide perovskite single crystals were produced and thoroughly described by a multi-technique approach to clarify their structural, electrical, optical, thermal, mechanical, and functional properties. Single-crystal X-ray diffraction (SCXRD) identified the Pna21 space group and molecular arrangement, while scanning electron microscopy (SEM) demonstrated the continuous atomic arrangement inside the crystal lattice. X-ray photoelectron spectroscopy (XPS) confirmed the elemental composition and oxidation states, thereby affirming the chemical stability of the material. Investigations of the frontier molecular orbitals (HOMO-LUMO) and non-covalent interactions (NCI) provided comprehensive insights into the electronic structure and intermolecular interactions, confirming the stability of the system. The Vickers microhardness technique was employed to evaluate mechanical resilience, revealing that the crystals exhibit modest resistance to deformation. DSC and TGA verified the material's thermal stability up to 200 °C. Impedance and modulus spectroscopy clarified the conduction mechanism and validated the transition from non-Debye to Debye behavior in the chemical as a function of temperature. The optical band gap investigation revealed a direct allowed transition with a band gap of 1.75 eV, indicating its appropriateness as a semiconductor for optoelectronic applications. The material demonstrated significant humidity sensing capabilities, underscoring its potential for environmental monitoring applications.

7-6

# Comprehensive investigation of environmental degradation pathways and stability enhancement in $FAPbI_3$ perovskite films incorporating polyionic liquid (PIL) additives

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This study investigates the environmental stability and degradation behavior of $FAPbI_3$ perovskite films under exposure to moisture, UV irradiation, and elevated temperatures. The analysis compares pristine $FAPbI_3$ films with those modified by polyionic liquid (PIL) additives. Two PIL additives were used: a Li-based additive (PIL 1) and an imidazolium-based additive (PIL 2). A combination of characterization techniques, including UV-Vis spectroscopy, X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and scanning electron microscopy (SEM), was employed to monitor optical, structural, and morphological changes during degradation. Results reveal that pristine $FAPbI_3$ rapidly converts into the non-conductive δ-phase under humid conditions, while the films containing PILs exhibit significantly improved stability. Under UV exposure the PIL-modified films retain the perovskite α-phase longer and show slower spectral and morphological changes. Thermal degradation tests revealed that films containing PIL additives exhibited prolonged stability, with $PbI_2$ formation, an indicator of degradation, occurring only after an extended exposure period. Both additives markedly improve the stability and morphology of the films under different environmental stress conditions, confirming the stabilizing role of polyionic liquids in enhancing the environmental resilience of $FAPbI_3$ perovskite films.

8-1

# Thin film heterostructures by reactive sputtering: from interface engineering to defect control

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Thin film heterostructures offer a versatile platform for tuning the structural and electronic properties of semiconductors, enabling their application in photocatalysis, energy conversion, and storage. Reactive sputtering is particularly attractive for this purpose, as it provides precise control of stoichiometry, film thickness, and interfacial quality, while post-deposition modification strategies allow further tailoring of material properties. Approaches such as thermal annealing, and secondary material deposition can introduce controlled defect states, adjust band alignment, and enhance charge transport. As representative examples, $TiO_2$/TiN bilayers fabricated by reactive sputtering and subsequently annealed demonstrated nitrogen incorporation across the interface, leading to visible-light activation and improved photocatalytic performance. In a complementary study, sputter deposition of Ta onto $TiO_2$ nanotubes induced the formation of $\beta$-$Ta_2O_5$ and oxygen vacancies, resulting in enhanced conductivity and electrochemical capacity. These cases highlight the broader principle that the combination of reactive sputtering with targeted modification enables fine-tuning of thin film heterostructures at the atomic level. Such synthesis-driven engineering strategies represent a scalable pathway for developing advanced multifunctional materials with optimized optical, electronic, and catalytic properties.

8-2

# Optimization of electrochemical deposition parameters for $NiMoO_x$ electrocatalysts for the hydrogen evolution reaction

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The hydrogen evolution reaction (HER) has been considered as one of the main challenges in the transition toward sustainable hydrogen energy, primarily due to the reliance on precious metals such as platinum and iridium as catalysts. This study was focused on developing cost-effective $NiMoO_x$ composite coatings capable of achieving comparable or superior catalytic performance and stability under harsh industrial conditions. The influence of deposition parameters on the morphology and electrocatalytic activity of the prepared electrodes was systematically investigated. The electrodes were synthesized by electrochemical deposition under varying current densities, concentrations of non-metallic particles, deposition times, stirring rates, and electrolyte flow rates. Importantly, the $NiMoO_x$ powder used for electrode fabrication was synthesized in the laboratory rather than obtained commercially, ensuring better control over composition, particle size, and phase purity. This approach resulted in coatings of higher quality and reproducibility. Surface morphology was characterized using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS), while catalytic performance and reaction kinetics were evaluated through polarization curves and electrochemical impedance spectroscopy (EIS). The results showed that variations in deposition parameters significantly affected grain size, porosity, and the electrochemically active surface area, determining parameters for the activity toward the HER. Optimized deposition conditions yielded a cauliflower-like surface morphology with a high density of active sites, resulting in enhanced HER activity and excellent long-term stability. The best-performing electrode exhibited an overpotential of −81 mV at a current density of −1000 mA $cm^{-2}$, confirming the high efficiency of the developed catalyst. These findings demonstrate that both the synthesis of the precursor powder and the precise control of deposition parameters were crucial for optimizing the morphology and performance of low-cost $NiMoO_x$ electrocatalysts for HER.

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8-3

# Enhancing solubility of ellagic acid from raspberry biomass using ionic liquids

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Ellagic acid (EA) is a naturally occurring polyphenolic compound widely present in fruits and berries, recognized for its strong antioxidant, anticarcinogenic, and anti-inflammatory properties. It has been associated with potential protective effects against cancer, cardiovascular diseases, and neurodegenerative disorders. However, its broader therapeutic and commercial applications remain limited due to its poor water solubility and low bioavailability, which also make its extraction from plant materials and incorporation into functional formulations challenging. Traditional extraction methods employing organic solvents such as methanol, ethanol, or acetone are often inefficient, environmentally unsustainable, and inadequate for dissolving hydrophobic compounds like EA. In recent years, ionic liquids (ILs) and natural deep eutectic solvents (NADES) have emerged as promising green alternatives for the extraction of phenolic compounds. Composed of renewable and non-toxic components, these solvents offer tunable solvation capacity, enhanced extraction efficiency, and a low environmental impact, aligning closely with the principles of sustainable chemistry. In this study, whole raspberries and raspberry pomace were investigated as raw materials for ellagic acid extraction. Samples were lyophilized and extracted using 20% aqueous cholinium-based ionic liquids. Six cholinium chloride–based ionic liquids were applied as extraction media, while water and ethanol served as reference solvents for comparison. The obtained extracts were analyzed using HPLC-DAD. All tested ILs significantly enhanced the EA yield compared to water and ethanol, with cholinium acetate proving to be the most efficient, particularly in extractions from raspberry pomace. Furthermore, freeze-dried raspberry pomace yielded higher EA concentrations than whole raspberries, confirming that both solvent composition and biomass pretreatment are key factors of extraction efficiency. Overall, these results demonstrate that cholinium-based ionic liquids are highly effective green solvents for the sustainable extraction of ellagic acid and other phenolic compounds from raspberry-processing residues, thereby supporting the valorization of agro-industrial by-products and the advancement of environmentally responsible extraction technologies.

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8-4

# Chemical characterization and cytotoxic profile of cocoa bean shell (*Theobroma cacao L.)* extract as a potential cosmetic ingredient

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The cocoa bean shell (*Theobroma cacao* L.) represents a significant by-product of the confectionery industry, generated during the removal of the outer seed coat after the roasting process and accounting for approximately 12–20% of the total bean mass. Traditionally treated as waste, this biomass is increasingly recognized as a secondary raw material suitable for valorization across various industrial sectors, including food, cosmetic, and biotechnological applications. Such an approach aligns with the principles of the circular economy, which emphasize closing material loops through waste reduction, reuse, and resource recycling, thereby improving both environmental performance and the economic efficiency of production systems. In the present study, extraction of the cocoa bean shell was carried out using aqueous Soxhlet extraction. The obtained extract was chemically characterized through the determination of total polyphenol content (TPC), total flavonoid content (TFC), antioxidant capacity (DPPH and ABTS methods), and sun protection factor (SPF). TPC, determined using the Folin-Ciocalteu method, amounted to 8.13±0.59 mg gallic acid equivalent/100 mg of dried extract, while TFC was 2.37±0.05 mg catechin equivalent/100 mg of dried extract. The $IC_{50}$ value (the concentration of the extract required to neutralize 50% of free DPPH radicals) was 4.05±0.02 mg/mL, and the anti-ABTS potential was 28.89±3.11 mmol Trolox equivalent/g of dried extract. SPF, determined using the *in vitro* spectrophotometric method and the Mansur equation, varied in the range of 0.94-21.40, depending on the tested concentration of the extract (175-3000 µg/mL). Cytotoxicity of the extract was assessed using the MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay on human fibroblasts (MRC-5). The starting extract concentration of 21.1 mg/mL was diluted in medium to 2×, 4×, 8×, 16×, 32×, and 64×. Significant cytotoxicity was observed at 2× and 4× dilutions ($p < 0.001$), partial recovery of cell viability at 8× ($p < 0.001$), a mild but significant effect at 16× ($p < 0.05$), while 32× and 64× dilutions showed no statistically significant effect compared to the control ($p > 0.05$), indicating the absence of cytotoxicity at these concentrations. One-way ANOVA ($F = 449.6$; $p < 0.0001$) confirmed significant differences between treated groups. Dunnett's *post hoc* test was used to compare each treatment with the control. These findings highlight the notable potential of cocoa bean shell extract as a natural antioxidant and auxiliary UV filter for incorporation into cosmetic formulations.

8-5

# pH-responsive anthocyanin–biopolymer films as smart food freshness indicators

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Food waste from fresh fruit and vegetable processing is an increasing global concern, as its decomposition produces gaseous byproducts with varying chemical compositions and pH values. Anthocyanins are natural pigments present in various fruits and vegetables, known for their ability to change color in response to pH variations. In this study, anthocyanins were obtained from different fruit wastes: red grape skin, blueberries, and raspberries using microwave-assisted extraction (MAE) technology. First, the fruit waste was lyophilized and the MAE was carried out from lyophilized material in 60% (v/v) ethanol solution in water. The extraction conditions were optimized by varying several parameters: material-to-solvent ratio, temperature, power, and extraction time. UV-Vis spectroscopy confirmed the presence of anthocyanins in the obtained extracts with characteristic peaks observed at wavelengths of 280 and 520 nm. Chemical composition of the extracts was determined using high performance liquid chromatography. The main active component in the grape skin extract was identified as cyanidin-3-O-glucoside, in raspberry and blueberry skin extracts, delphinidin-3-O-glucoside was predominant. Biopolymer-based matrices, containing chitosan/glycerol in ratio 70/30, were prepared with addition of different concentrations of extracts (10%, 15% and 20% (v/v)). The prepared solutions were poured into Petri dishes, and after drying in a vacuum oven, biopolymer films were obtained. The stability of the extracts and matrices was determined by measuring zeta potential, which was in the range from -14 mV up to -20 mV for extracts and around 35 mV for extract-biopolymer combinations. pH-responsiveness of the films was tested in contact with solutions covering a range of pH values. A rapid and visually detectable color change was immediately observed, indicating the films' sensitivity to pH variations.

8-6

# Application of the briggs-rauscher oscillatory reaction for the identification of phosphate-tungsten bronzes

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In this work, undoped phosphate-tungsten bronze (PWB) and phosphate-tungsten bronzes doped with cations from the first and second periods of the Periodic Table (Li-PWB and Ca-PWB) and rare-earth elements (Ce-PWB and Pr-PWB) were successfully synthesized by thermal treatment of 12-tungstophosphoric heteropoly acid and its salts. The obtained materials were characterized using TGA, DTA, DSC, FTIR, XRPD, ICP-OES, SEM, SEM-EDX, and PL techniques. Since phosphate-tungsten bronzes are still insufficiently studied, the Briggs-Rauscher (BR) oscillatory reaction, susceptible to external additives, was applied to identify and examine their properties. The effect of different amounts of PWB, Li-PWB, Ca-PWB, Ce-PWB, and Pr-PWB on the BR reaction dynamics were analyzed by monitoring the oscillation period as a function of the added bronze mass. All bronzes significantly influenced the BR oscillatory period, with undoped PWB showing the strongest effect, generally shortening the oscillations. PWB, Li-PWB, and Ca-PWB exhibited linear dependencies (with distinct slopes), whereas Ce-PWB and Pr-PWB showed nonlinear, exponentially decreasing responses. Variations in the oscillatory behavior enabled differentiation among the bronzes and provided insights into their catalytic characteristics.

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8-7

# New poly(carboxy-)/poly(sulfobetaine methacrylate) based materials as transdermal patches for quinine hydrochloride delivery

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Developing new vehicles for drug delivery is a major milestone in addressing challenges associated with treating and preventing the spread of malaria, particularly in low-resource African regions where access to healthcare services is limited. Polymers with smart behavior are promising materials for the development of advanced drug delivery systems. A smart polymer is one that can respond to external stimuli such as changes in pH, temperature, or ionic strength, enabling controlled drug release and improved treatment effectiveness. In this work, we have synthesized nanoparticles based on poly(carboxybetaine methacrylate) (PCB), a zwitterionic polymer able to respond to pH and ionic strength changes, and loaded them with quinine hydrochloride (QH), a well-known antimalarial drug. The QH-loaded nanoparticles were then embedded in a matrix made of poly(sulfobetaine methacrylate) (PSB), another zwitterionic smart polymer known to response to changes in temperature and ionic strength. Combining both types of zwitterionic polymers that respond to different external stimuli allows modification of the QH release profile, making it more appropriate for transdermal drug delivery, e.g. aiming to improve malaria treatment effectiveness and reducing frequency of QH administration. The size of PCB nanoparticles as well as their behavior under different conditions, e.g. temperature, pH and salt concentration, were investigated. Moreover, QH entrapment efficiency and release profiles from both the PCB nanoparticles and the PCB-loaded PSB hydrogels were evaluated to assess their potential as system for transdermal QH delivery.

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9-1

# Theoretical prediction and experimental validation of temperature-dependent raman spectra of doxorubicin

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Temperature-dependent Raman spectra of doxorubicin (DOX) show pronounced changes in band intensities between 100 and 300 K. Detailed analysis and comparison with simulated resonance Raman spectra indicate that these variations arise primarily from temperature-dependent resonance effects. The GOAT algorithm, implemented through the ORCA program, was employed to identify isomers of neutral DOX, DOX-HCl, and DOX-$H^+$. The most stable structures were optimized, and harmonic vibrational frequencies and Raman activities were computed at the R2SCAN/def2-TZVP level of theory with D3 dispersion corrections. The observed temperature-dependent spectral features were successfully reproduced by resonance Raman calculations that included spectral broadening, anharmonic scaling, and Duschinsky rotation effects. Quantitative comparison using the SARA algorithm yielded 91–94% agreement between theory and experiment across all temperatures. Increasing temperature was found to weaken hydrogen-bonding modes while enhancing collective ring vibrations, consistent with reduced hydrogen-bond strength and increased vibrational delocalization.

9-2

# Unveiling new spin states in NiO and PdO: A computational exploration of polymorphism

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Binary oxides of palladium and nickel play a crucial role in industry due to their wide range of technological applications, stemming from their diverse properties that range from semiconducting behavior to catalytic and photocatalytic activity. In both cases, only the simple oxides—NiO and PdO—are well characterized. Despite broad range of existing applications for NiO and PdO, the possible polymorphism in these bianry oxides has received relatively little attention to date. In our work, we employ evolutionary algorithms combined with density functional theory (DFT) to explore the potential polymorphism of NiO and PdO. Our primary focus is on identifying previously unknown spin states of these oxides—specifically, a possible high-spin structure for PdO and a low-spin structure for NiO. The insights gained from this study may open new pathways for tuning the electronic and catalytic properties of these technologically important materials.

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9-3

# Vibrational properties of SrIrO3 thin films grown on various substrates

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Ruddlesden-Popper series of 5d strontium-irridates ($Sr_{n+1}Ir_nO_{3n+1}$) are one of the most extensively studied classes of materials in the last few years due to spin-orbit coupling, crystal field and electronic correlations of similar strength. This enables transitions between electronic states provoked by slight structural or chemical changes. In this work Raman scattering spectra of $SrIrO_3$ (SIO) thin films, grown on four substrates (LAO, LSAT, STO, GSO) are studied in various experimental conditions. Our attention is focused on Raman mode appearing at 395 $cm^{-1}$, with Ag symmetry. This mode shifts to higher wavenumber when going from SIO/GSO, through SIO/STO and SIO/LSAT, and finally to SIO/LAO sample, which reflects gradual increase of compressive strain induced by the substrate.

9-4

# Epitaxial growth of monocrystalline palladium oxide nanoparticles on rutile substrates

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This work presents the epitaxial growth of monocrystalline palladium oxide nanoparticles with high oxidation states using magnetron sputtering on rutile substrates. The approach enabled the formation of well-ordered PdO nanoparticles and potentially new Pd–O oxide phases predicted by density functional theory (DFT). The novelty of this work lies in the epitaxial synthesis of palladium oxides in nanoparticle form by magnetron sputtering, which has not been previously reported. High-resolution transmission electron microscopy (HRTEM) and nano-EDS analyses revealed the epitaxial alignment of the nanoparticles with the rutile substrate. The developed growth method provides a new pathway toward controlled synthesis of palladium oxide nanoparticles and offers promising prospects for catalytic and functional oxide applications.

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9-5

# Influence of different modification and functionalization strategies of graphene quantum dots on singlet oxygen production

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Photodynamic therapy (PDT) has emerged as an effective and minimally invasive approach for treating a wide range of diseases. It relies on photosensitizers that convert light energy into reactive oxygen species (ROS) through interactions with molecular oxygen. Graphene quantum dots (GQDs) have recently gained attention as promising photosensitizers due to their strong light absorption, tunable photoluminescence, and high biocompatibility. When exposed to specific wavelengths of light, GQDs can generate ROS, including singlet oxygen ($^1O_2$), which inactivate key microbial enzymes such as superoxide dismutase and catalase, thereby reducing the development of resistance. Due to its localized activation and non-invasive nature, PDT offers significant advantages over conventional therapies, including fewer side effects and improved treatment selectivity. In this study, different modifications of GQDs and their effect on $^1O_2$ production were investigated. Firstly, the GQDs were functionalized with L-cysteine under gamma irradiation at doses of 25, 50, and 200 kGy, and these samples are labeled as GQD-cys-25, GQD-cys-50, and GQD-cys-200. Subsequently, p-GQDs and GQD-cys-25 were further functionalized with gold nanoparticles (AuNPs) and irradiated with doses of 1 and 20 kGy. The resulting samples are labeled as p-GQD-AuNPs (1 and 20 kGy) and GQD-cys-AuNPs (1 and 20 kGy). Photo-induced $^1O_2$ production was investigated using electron paramagnetic resonance (EPR) spectroscopy and spectrophotometric analysis with specific probe molecules, 9,10-anthracenediyl-bis(methylene)dimalonic acid (ABDA) and 1,3-diphenylisobenzofuran (DPBF). The results showed that under blue light (470 nm), GQD-cys-25 produced $^1O_2$ within 5 min, while GQD-cys-50 and GQD-cys-200 required 7–8 min to reach the same effect, as confirmed by DPBF degradation. For AuNP-modified samples, p-GQD-AuNPs 1 kGy showed continuous $^1O_2$ production with a maximum ABDA degradation observed at 150–210 min, and GQD-cys-AuNPs 1 kGy reached a similar efficiency slightly later. The calculated $^1O_2$ quantum yields under blue light were $0.459 \pm 0.030$ for p-GQD-AuNPs 1 kGy and $0.392 \pm 0.022$ for GQD-cys-AuNPs 1 kGy. These results show that different methods of GQD modification strongly affect $^1O_2$, with GQD-cys-25 and p-GQD-AuNPs 1 kGy showing the fastest and most stable $^1O_2$ generation. These findings highlight the strong potential of modified GQDs as effective photosensitizers for PDT.

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9-6

# Polystyrene nanosized dots: structure and optical properties

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Nowadays, modern civilization uses around 30% of objects that are made of the plastics. Disposed plastic can be found in water, in soil, in the air and even in living organisms. Plastic enters living organisms through water and food. Thus, plastics used can harm human health. In everyday life, polystyrene (PS) is one of the most used plastics that is hard to recycle. In this research, the structural and chemical properties of PS based micro and nanoplastics were studied. Namely, commercially available PS (Styrofoam) was dissolved in chloroform. The obtained colloid was irradiated by gamma rays at doses of 300, 400, 500 and 600 kGy, respectively. Thus, PS based micro and nanosized particles were synthesized and further characterized by different techniques. Nanomechanical and nano-electrical properties were investigated by using atomic force microscope (AFM) in order to determine Young's modulus of elasticity and charge distribution of PS particles synthesized respectively. Particle size distribution, height and shape of PS particles were determined by AFM as well. To check chemical composition, different techniques were used: Fourier transform infrared spectroscopy (FTIR) and Raman spectroscopy. The optical properties of the samples were studied by using photoluminescence (PL) and ultraviolet–visible (UV–Vis) spectroscopy. The PS particles have a size from 183 to 112 nm. They are positively and negative charged depending on the applied irradiation dose. PS particles irradiated at 600 kGy have doughnut like shape and their Young's modulus of elasticity is around 400 MPa. Chemical analysis conducted by FTIR shows that all samples are composed of C, O, and H atoms dominantly with C-H, C=O, C-C and C-O characteristic bonds. Partial carbonization of PS nanoparticles is established from the Raman spectra, which is also confirmed by AFM. In the UV-Vis spectra of all PL particles we noticed pick at 260 nm. PL spectra of PS particles irradiated at 600 kGy show that these spectra have emission-excitation dependence.

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10-1

# Influence of synthesis route on the supercapacitor performance of graphene oxide-based composites

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The influence of synthesis route on the supercapacitor performance of graphene oxide (GO)-based composites was systematically investigated in a representative case involving cobalt ferrite nanoparticles. Particular emphasis was placed on understanding how surfactant presence and post-synthesis processing affect the electrochemical behavior of the resulting materials. Three nanoparticle synthesis strategies were explored: preparation with surfactant, preparation without surfactant, and synthesis with surfactant followed by its removal through thermal treatment prior to composite formation. The composites were then fabricated either through direct hydrothermal treatment or by mixing pre-formed nanoparticle and GO suspensions followed by thermal treatment in an inert atmosphere. In addition, the nanoparticle loading was varied between 15 wt% and 30 wt%, and a simultaneous hydrothermal synthesis of nanoparticles and composite from precursors was also evaluated. Galvanostatic charge–discharge measurements revealed a strong dependence of capacitance on both synthesis route and interfacial assembly conditions. The composite prepared via the hydrothermal route with 15 wt% nanoparticle content synthesized in the presence of surfactant exhibited the highest specific capacitance among all samples. This enhancement is attributed to improved nanoparticle dispersion, stronger coupling between GO sheets and active particles, and the preservation of oxygen functionalities beneficial for charge storage. These findings demonstrate that careful control of synthesis pathways—particularly the use of surfactant-assisted hydrothermal processing—plays a decisive role in optimizing the electrochemical performance of GO-based supercapacitor materials.

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# Oxidation methods of single-walled carbon nanotubes

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Chemical surface modification of carbon nanotubes, through the introduction of polar functional groups, significantly improves their solubility and dispersibility in polar media. Numerous oxidation procedures for single-walled carbon nanotubes (SWCNTs) have been reported in the literature, including wet chemical methods (using $HNO_3/H_2SO_4$ mixtures, $KMnO_4$, $H_2O_2$, or Fenton reagents), photocatalytic, electrochemical, and thermo-/catalytic oxidation in the presence of air, as well as ozonolysis, plasma treatments ($O_2$/Ar plasma), and sonochemical oxidation. In addition, several "greener" oxidation approaches have recently been developed. In this study, we present a comparative analysis of oxidized SWCNT products obtained through conventional wet-chemical and sonochemical oxidation, complemented by microwave-assisted methods and multistep synthesis of polyhydroxylated SWCNTs. The resulting derivatized materials were analysed and characterized using scanning electron microscopy (SEM), X-ray diffraction (XRD), Raman spectroscopy, and thermogravimetric analysis (TGA). The obtained results of modified SWCNTs indicate successful oxidation by various wet-chemical methods compared to the pristine material (99% SWCNT, OCSiAl, diameter $\approx$ 1.5 nm, length 1–5 μm).

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# Investigating structural and optical properties of $Eu^{3+}$-doped $MgGd_2Zr_2O_8$ for application in optical thermometry

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This study presents the synthesis and characterization of a novel luminescent material, $MgGd_2Zr_2O_8$ doped with (2, 5, 10, 15, 20, and 25 at%) $Eu^{3+}$ ions, and explores its potential application in optical thermometry. The samples were synthesized via a simple sol–gel route and subsequently thermally treated for 4 hours at 850 °C. X-ray powder diffraction (XRPD) analysis combined with Rietveld refinement revealed that the obtained samples crystallize in a fluorite-type cubic structure (space group $Fm\overline{3}m$), exhibiting crystallite sizes of approximately 7 nm and a lattice parameter expansion attributed to $Mg^{2+}$ ions preferentially occupying interstitial or vacant sites. Transmission electron microscopy (TEM) revealed that the material consists of irregularly shaped aggregates formed by the clustering of smaller particles (<100 nm). High-resolution TEM images confirmed the crystalline nature of the sample, with lattice planes consistent with XRPD results and crystallite sizes below 10 nm. Elemental mapping obtained through energy-dispersive spectroscopy (EDS) showed a homogeneous spatial distribution of all constituent elements. Photoluminescence (PL) spectra displayed characteristic $Eu^{3+}$ emission transitions from the $^5D_0$ excited state to the $^7F_J$ ($J = 1$–$4$) levels. The optimal dopant concentration was determined to be 15 at%, beyond which concentration quenching occurred. Temperature-dependent luminescence measurements were performed in the 300–550 K range using the luminescence intensity ratio (LIR) method, based on non-thermally coupled transitions $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_2$. The maximum relative sensitivity of 0.3 % $K^{-1}$ at 550 K was achieved for the $LIR_{592/612}$ ratio, while the $LIR_{586/612}$ ratio showed a more moderate, yet stable sensitivity of approximately 0.1 % $K^{-1}$ at temperatures above 430 K.

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# Influence of the graphene oxide content in the ZnO/GO composite on the selectivity and sensitivity of the electrode for detecting diclofenac in water

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Diclofenac (DCF) is one of the most commonly used pharmaceuticals today. Due to its high consumption, DCF ends up in ecosystems and watercourses, where it becomes a pollutant, endangering the living world. Effective monitoring of contaminant concentrations in water is crucial for ensuring water quality, which can be achieved through electroanalytical methods. The performance of an electrochemical method is critically determined by the surface characteristics of the working electrode. Therefore, composites were designed to modify the surface of the working electrode to improve its properties. In this study, we propose zinc oxide/graphene oxide (ZnO/GO) composites with different weight percentages of GO relative to ZnO (0.005%, 0.01%, and 0.05%) to examine the influence of GO content on the characteristics of the electrode for the detection of DCF in water. The physicochemical characteristics of the materials were examined by X-ray diffraction analysis, Raman spectroscopy, and FESEM imaging. The materials were then combined with the carbon additive, distilled water, and ethanol into an ink to modify the glassy carbon electrode. After In Situ electrochemical reduction of GO, the obtained electrodes were tested for the oxidation of DCF in a neutral electrolyte (0.1 M phosphate buffer) by cyclic voltammetry (CV). CVs showed an irreversible anodic peak originating from the oxidation of DCF, as well as anodic and cathodic peaks originating from the oxidation/reduction of the decomposition product of the oxidized form of DCF. Parameters such as limit of detection (LOD), limit of quantification (LOQ), dynamic range, and sensitivity were evaluated. The measurements indicated that all electrodes are selective for DCF. The proposed materials are suitable for further investigation in the field of electrochemical detection of pharmaceuticals in aqueous electrolytes.

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# Detection of doxorubicin from aqueous solution using ZnO/$BaTiO_3$-based nanocomposites

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Doxorubicin (DOX) is widely used as an anthracycline chemotherapeutic agent in various cancer treatments. Due to its persistence and potential environmental impact, the development of new methods for its detection is of great importance. Most often, spectrophotometric and chromatographic techniques are employed for DOX detection, though in recent years electrochemical methods have been increasingly investigated as promising alternatives. In this work, we studied ZnO/$BaTiO_3$ and ZnO/$BaTi_{0.95}Sn_{0.05}O_3$ nanocomposites as modifiers of glassy carbon electrodes for the electrochemical detection of DOX. The nanocomposite as the active material, carbon black as a conductive additive, and Nafion as a binder were mixed and applied to the glassy carbon electrode surface. The electrolyte was phosphate buffer solution (pH=7), and DOX was added in appropriate portions. Electrochemical measurements were performed using cyclic voltammetry (CV) and differential pulse voltammetry (DPV) in a three-electrode cell consisting of a modified glassy carbon working electrode, a platinum counter electrode, and a saturated calomel reference electrode. Both materials showed a well-defined oxidation peak corresponding to the redox process of DOX in both CV and DPV measurements. The limit of detection (LOD), limit of quantification (LOQ), dynamic range, and sensitivity were evaluated. The results indicate that ZnO/$BaTiO_3$ and ZnO/$BaTi_{0.95}Sn_{0.05}O_3$ nanocomposites may be used for DOX detection in aqueous solutions using electrochemical methods such as CV and DPV.

**Acknowledgements**: This research was supported by the Science Fund of the Republic of Serbia (The Program PRISMA, #7377, Water pollutants detection by ZnO-modified electrochemical sensors: From computational modeling via electrochemical testing to real system application – WaPoDe).

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# Exploration of electrodeposited carbon as a cathode for fully self-powered Al-air battery-based humidity sensor

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Fully self-powered humidity sensors are emerging as key components in next-generation Internet of Things (IoT) systems, enabling sustainable, maintenance-free environmental monitoring and smart infrastructure. This study explores the development of metal-air humidity sensors utilizing interdigitated electrodes fabricated from aluminium and carbon. In our previous work, we used photolithography to create interdigitated aluminium electrodes for humidity sensing. However, the design in which both sensor electrodes are made of the same material presents challenges due to polarity flipping. To address this issue, we propose a hybrid electrode design with aluminium serving as the anode and electrodeposited carbon as the cathode, leveraging carbon's well-established role in oxygen reduction reactions, which is one of the crucial reactions in metal-air batteries. The electrodeposition of carbon from ethanol allows for controlled hybridization by varying current density and temperature, potentially influencing sensor performance. The deposited layers will be characterized by using Raman spectroscopy, AFM, and KPFM, along with voltammetry to assess redox activity. Two sensor prototypes will be fabricated—one with all-aluminium electrodes and another with aluminium and electrodeposited carbon. Their humidity sensing performance will be compared. This approach aims to optimize electrode material selection and fabrication techniques for improved metal-air humidity sensors.

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# Synthesis, properties and electrochemical performances of novel pure and functionalized niobium MXenes

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MXenes, a family of two-dimensional transition metal carbides and nitrides, have attracted significant attention for energy storage applications due to their metallic conductivity, hydrophilic surfaces, and efficient ion transport. Among them, niobium carbide ($Nb_2C$) has emerged as a promising material for supercapacitor electrodes because of its high theoretical capacity and rapid ion diffusion. In this work, novel $Nb_2C$ MXene was synthesized in our laboratory, using the MILD etching method, enabling selective removal of aluminum from the $Nb_2AlC$ MAX phase and partial exfoliation into few-layer nanosheets. The synthesis conditions were optimized by varying the etching temperature, time, and etchant composition, while additional delamination was achieved using tetramethylammonium hydroxide (TMAH) solution. To further tailor the surface chemistry, the $Nb_2C$ was modified with three organo-silane coupling agents: γ-methacryloxypropyltrimethoxysilane (acrylate-silane) and 2-[methoxy(polyethyleneoxy)6–9propyl]trimethoxysilane (PEG-silane), and (3-aminopropyl)trimethoxysilane (amino-silane). The structural, surface and morphological properties were characterized by Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), Brunauer–Emmett–Teller (BET) analysis, water contact angle measurements, and scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDX). Electrochemical performances of the niobium MXene-based electrodes, such as the cycling stability, rate capability and capacitance, were investigated by electrochemical impedance spectroscopy (EIC), cyclic voltammetry (CV) and galvanostatic charge–discharge measurements (GCD) in a three-electrode setup with 3 mol $dm^{-3}$ KOH electrolyte. The results demonstrate that both the optimized synthesis procedure and surface functionalization significantly influence the structure–property relationships of novel $Nb_2C$ MXene, underscoring its strong potential for next-generation energy storage applications, such as in supercapacitors.

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# Stabilizing $WSe_2$ against uv-induced oxidation using thin hbn encapsulation layers

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Two-dimensional transition-metal dichalcogenides such as $WSe_2$ show excellent optoelectronic properties, yet their practical use is limited by rapid degradation when exposed to air, moisture and UV radiation. In this work, we demonstrate a simple and effective encapsulation strategy using ultrathin hexagonal boron nitride (hBN) films to protect mechanically exfoliated $WSe_2$ nanosheets. hBN films were prepared through a Langmuir–Blodgett deposition on PDMS stamp and then transfered on sample, enabling clean deposition without liquid immersion. Encapsulated and non-encapsulated $WSe_2$ samples on $Si/SiO_2$ substrates were subjected to controlled UV irradiation. Optical microscopy and Raman spectroscopy reveal pronounced structural degradation and formation of oxide-related Raman modes on unprotected $WSe_2$, while the encapsulated samples remained stable and preserved their characteristic spectral features. The results confirm that hBN films act as an efficient diffusion barrier against oxygen, moisture and UV-induced oxidation, significantly enhancing the environmental stability of $WSe_2$. This encapsulation approach provides a scalable and substrate-compatible route for protecting air-sensitive 2D materials in future nano-optoelectronic devices

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# CQDs as antibacterial photoactive agents in polyurethane coating

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Bacterial infections can easily spread over frequently touched surfaces like plastic, wood and metal, due to the growth of bacterial biofilms. Antibacterial materials that we can put on critical surfaces can eliminate or inhibit the growth of bacteria. In this study, we produced photoactive polyurethane coatings on the basis of carbon quantum dots (CQDs). This material has showed antibacterial activity against gram-positive (*Staphylococcus aureus*, *MRSA*, *Enterococcus faecalis*) and gram-negative (*Escherichia coli*, *Acinetobacter baumannii*) bacteria after 1 h of exposure to blue light. CQDs were synthesized using one-pot solvothermal method. Nicotinamide was used as started precursor. Polyurethane composites on the basis of CQDs were obtained by swelling-encapsulating-shrinking process. Obtained CQDs and their composites were structurally, chemically and optically analyzed. AFM and TEM images of CQDs have showed core-shell structure with average diameter of 45,9 ± 1,5 nm. Homogeneous encapsulation has been demonstrated using confocal Raman mapping. Production of ROS was investigated using spectroscopic methods (UV/Vis, PL and EPR). Therefore, it is assumed that $^1O_2$ and $^\bullet OH$ have a synergistic effect to bacteria membranes, causing their damage and the death of bacteria. The good biocompatibility of the obtained composites was investigated by MTT and hemolytic assays and their effect was analyzed on the HaCaT cells and erythrocytes. These materials have potential application as antibacterial coatings in healthcare and other institutions where control of the spread of bacterial infections is needed.

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# Microwave-assisted synthesis of carbon quantum dots for adsorption applications

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The increasing discharge of industrial effluents containing toxic organic dyes (Methylene Blue, Rhodamine B, Rose Bengal, etc.) has become a major environmental concern due to their persistence, stability, and harmful effects on aquatic ecosystems. Developing efficient, low-cost, and sustainable materials for dye removal is therefore of significant importance. Carbon Quantum Dots (CQDs) have attracted attention as a promising class of nanomaterials because of their high surface area, water solubility, tunable photoluminescence, and simple, eco-friendly synthesis routes. In this work, pristine CQDs were synthesised from simple carbon-based precursors (glucose) using a microwave-assisted method which provides rapid and uniform heating of the reaction mixture, enabling homogeneous formation of carbon nanoparticles within minutes. This green, one-step, low-cost, and energy-efficient approach significantly shortens the reaction time, reduces energy consumption, minimizes the formation of by product, and ensures high reproducibility. The resulting quasi-spherical CQDs exhibited uniform particle size distribution and abudant functional groups such as hydroxyl and carboxyl groups, enhancing their surface reactivity. The obtained CQDs exibited significant adsorption performance toward Methylene Blue, achieving 50% removal immediately upon mixing. This rapid and efficient dye adsorption can be attributed to multiple interaction mechanisms, including π-π stacking between aromatic rings, electrostatic attraction between charged sites, and hydrogen bonding with functional groupes on the CQD surface. These findings demonstrate the high potential of pristine CQDs as effective, sustainable, and scalable adsorbents for wastewater treatment applications.

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# $Cu^2$@$SiO_2$ nanocomposites for antimicrobial surfaces

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Antimicrobial surfaces are increasingly needed to limit pathogen transmission on high-touch surfaces, which account for up to 40% of hospital-acquired infections. While many coatings show strong laboratory efficacy, they often fail under real-world conditions such as organic soiling, periodic washing and routine wear, all leading to a rapid loss of antimicrobial activity due to depletion of the active compound. Achieving durable and long-lasting coatings requires the development of wear-resistant systems capable of controlled release of antimicrobial agent. In this work, we developed mesoporous silica ($SiO_2$) nanocarriers prepared using a modified Stöber method for the in-pore encapsulation of copper salts. Composition and morphology were characterized by X-ray Diffraction (XRD), Total Reflection X-ray Fluorescence (TXRF), X-ray Photoelectron Spectroscopy (XPS), Scanning Electron Microscopy (SEM), and Transmission Electron Microscopy (TEM). The release mechanism is based on the diffusion of $Cu^{2+}$ ions from the intrapore reservoirs into the environment, driven by the concentration gradient. The silica framework prevents uncontrolled leaching, ensuring a slow, sustained, and reproducible release. This chemical strategy combines the antimicrobial redox activity of copper ions with the chemical and mechanical stability of silica, thereby enhancing durability under real-life conditions. The antibacterial activity of Cu@$SiO_2$ nanocomposites was evaluated against clinically relevant bacteria *Escherichia coli, Pseudomonas aeruginosa*, and *Staphylococcus aureus,* using a cell viability assay (spot test). Preliminary results showed that Cu@$SiO_2$ exhibited up to 5-fold higher antimicrobial activity compared to both copper sulfate ($CuSO_4$, an ionic control) and mesoporous silica nanocarriers without copper. The 24-h minimum bactericidal concentrations (MBCs) of Cu@$SiO_2$ against the tested bacteria were in the range of 0.1–0.5 mg Cu/L. This synthesis approach offers tunable loading and gradual ion release, addressing one of the main gaps in the field: durability under application-relevant conditions. These findings highlight the potential of mesoporous silica nanocomposites as next-generation antimicrobial coating materials for use in hospitals, food packaging, and public infrastructure.

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