INSTITUTE OF TECHNICAL SCIENCES OF SASA
MATERIALS RESEARCH SOCIETY OF SERBIA

*Programme and the Book of Abstracts*

# TWENTIETH YOUNG RESEARCHERS' CONFERENCE MATERIALS SCIENCE AND ENGINEERING

Belgrade, November 30 – December 2, 2022

**TWENTIETH YOUNG RESEARCHERS' CONFERENCE**
# MATERIALS SCIENCE AND ENGINEERING

**November 30 – December 2, 2022, Belgrade, Serbia**

# Programme and the Book of Abstracts

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

2022

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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 «Programme 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 2023.

## Sponsors


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# Programme
# Twentieth Young Researchers Conference
# Materials Science and Engineering

## Wednesday, November 30, 2022

### 09.00 – 09.30 Opening Ceremony

### 09.30 – 11.15 1st Session – Biomaterials I
### Chairpersons: Prof. Dr. Bojana Obradović and Francesco Colella

**09.30 – 09.45 Evaluation of cytotoxic and hemostatic effects of polymethylmethacrylate, polymethylmethacrylate enriched with chitosan and polymethylmethacrylate enriched with silver chloride**
Nemanja Mladenović[1], Milena Kostić[2], Nikola Gligorijević[2], Ljubiša Nikolić[3], Perica Vasiljević[1]
*[1]Department of Biology and Ecology, Faculty of Science and Mathematics, University of Niš, 18000 Niš, Serbia, [2]Department of Prosthodontics, Faculty of Medicine, University of Niš, 18000 Niš, Serbia, [3]Faculty of Technology, University of Niš, 16000 Leskovac, Serbia*

**09.45 – 10.00 Synthesis and characterization of dental inserts based on calcium-phosphate, doped with magnesium, strontium and fluorine ions**
Jelena Stanisavljević[1], Tamara Matić[2], Zvezdana Baščarević[3], Đorđe Veljović[1]
*[1]University of Belgrade – Faculty of Technology and Metallurgy, Belgrade, Serbia, [2]University of Belgrade – Innovation Center of Faculty of Technology and Metallurgy, Serbia, [3]Institute for Multidisclipinary Research, University of Belgrade, Serbia*

**10.00 – 10.15 A pH-Sensor scaffold for mapping spatiotemporal gradients in three-dimensional in vitro tumour models**
Riccardo Rizzo[1], Valentina Onesto[1], Stefania Forciniti[1], Anil Chandra[1], Saumya Prasad[1], Helena Iuele[1], Francesco Colella[1,2], Giuseppe Gigli[1,2], Loretta L. Del Mercato[1]
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*[2]Department of Mathematics and Physics ''Ennio De Giorgi", University of Salento, via Arnesano, 73100, Lecce, Italy*

**10.15 – 10.30 Mechanical properties and bioactivity of scaffolds based on calcium-phosphates doped with $Mg^{2+}$, $Sr^{2+}$ and $F^-$ ions and coated with chitosan**
Teodora Jakovljević[1], Tamara Matić[1], Julijana Tadić[2], Đorđe Veljović[3]
*[1]Innovation Center of Faculty of Technology and Metallurgy, Serbia, [2]Vinča Institute of Nuclear Science, University of Belgrade, Serbia, [3]University of Belgrade – Faculty of Technology and Metallurgy, Belgrade, Serbia*

**10.30 – 10.45 Synthesis and characterization of composite resveratrol/selenium nanomaterial, and preliminary assessment of its' antioxidative effect and biocompatibility**

Nina Tomic[1], Nenad Filipovic[1], Dragana Mitic Culafic[2], Magdalena Stevanovic[1]
*[1]Institute of Technical Sciences of SASA, Knez Mihailova 35/IV 11000 Belgrade, Serbia*
*[2]University of Belgrade – Faculty of Biology*

**10.45 – 11.00 Stability of phospholipid liposomes with encapsulated *Rosa canina* L. seed oil**

Natalija Čutović[1], Jelena Živković[1], Katarina Šavikin[1], Branko Bugarski[2], Aleksandar Marinković[2], Danica Ćujić[3], Aleksandra A. Jovanović[3]
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**11.00 – 11.15 Encapsulation of nutrients using proteins derived from leaves**

Olivera Vukoičić[1], Neda Pavlović[2], Zorica Knežević-Jugović[1]
*[1]University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, 11120 Belgrade, Serbia,[2]University of Belgrade, Innovation Center of Faculty of Technology and Metallurgy, Karnegijeva 4, 11120 Belgrade, Serbia*

**11.15 – 11.30 Break**

## 11.30 – 13.15 2nd Session – Biomaterials II
## Chairpersons: Dr. Ivana Drvenica and Ivana Banićević

**11.30 – 11.45 Development of a physiologically relevant osteosarcoma model based on alginate scaffolds and perfusion bioreactor**

Mia Milošević[1,2], Ivana Banićević[1], Marija Pavlović[1], Milena Milivojević[3], Milena Stevanović[3,4,5], Jasmina Stojkovska[1,2], Bojana Obradović[1]
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**11.45 – 12.00 Cellular self-assembly in a 3D osteosarcoma culture model based on alginate scaffolds and perfusion bioreactor**

Ivana Banićević[1], Ksenia Menshikh[2], Mia Radonjić[1], Jelena Petrović[1], Radmila Janković[3], Milena Milivojević[4], Milena Stevanović[4,5,6], Jasmina Stojkovska[1,7], Bojana Obradović[1]
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**12.00 – 12.15 Osteosarcoma *In Vitro*: a Step-by-Step Approach**

Ksenia Menshikh[1], Ivana Banicevic[2], Mia Radonjic[2], Marta Miola[3], Jasmina Stojkovska[2,4], Andrea Cochis[1], Bojana Obradovic[2], Lia Rimondini[1]
*[1]Università del Piemonte Orientale, Center for Translational Research on Autoimmune and Allergic Disease, Novara, Italy, [2]University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia, [3]Politecnico di Torino, Institute of Materials Engineering and Physics, Turin, Italy, [4]Innovation Center of the Faculty of Technology and Metallurgy, Belgrade, Serbia*

**12.15 – 12.30 Optimization of cell culture conditions for neural differentiation of NT2/D1 cells in alginate microfibers**

Jelena Pejić[1], Marija Mojsin[1], Jasmina Stojkovska[2], Milena Stevanović[1,3,4], Bojana Obradović[5], Milena Milivojević[1]
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**12.30 – 12.45 Glucosomes: Magnetically induced controlled release of glucose modified liposomes**

Đorđe Cvjetinović[1,2], Zorana Milanović[3], Marija Mirković[3], Jelena Petrović[3], Ana Vesković[2], Ana Popović-Bijelić[2], Drina Janković[3], Sanja Vranješ-Đurić[3]
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**12.45 – 13.00 Bioactives preservation of everlasting (*Helichrysum plicatum* L.) flowers extract by freeze drying method and powder characterisation**

Zorana Mutavski[1], Nada Ćujić Nikolić[1], Milica Radan[1], Dubravka Bigović[1], Smilja Marković[2], Katarina Šavikin[1]

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**13.00 – 13.15 Microencapsulation of Oregano and Thyme essential oils with hydroxypropyl-β-cyclodextrin**

Snežana Kuzmanović Nedeljković[1], Nada Ćujić Nikolić[1], Dubravka Bigović[1], Predrag Petrović[2], Dejan Pljevljakušić[1], Katarina Šavikin[1], Brankica Filipić[3]

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**13.15 – 14.15 Lunch break**

## 14.15 – 15.45 3rd Session – Biomaterials III
## Chairpersons: Dr. Đorđe Veljović and Marta Tavoni

**14.15 – 14.30 Bioactive hydroxyapatite/chitosan/poly(vinyl alcohol)/gentamicin composite coating electrodeposited on titanium**

Milena Stevanović[1], Ana Janković[1], Marija Djošić[2], Maja Vukašinović-Sekulić[1], Vesna Kojić[3], Vesna Mišković-Stanković[4]

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**14.30 – 14.45 Properties of Ti-O ALD films on $CN_x$ and nanolayer TiAlSiN PVD coatings intended for orthopedic implant applications**

Zoran Bobić[1], Vladimir Terek[1], Lazar Kovačević[1], Branko Škorić[1], Attila Csik[2], Miha Čekada[3], Ivan Čapo[4], Pal Terek[1]

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**14.45 – 15.00 Toward new therapies for the treatment of bone cancer: calcium phosphate-based cement as tuneable system for Doxorubicin delivery**
Marta Tavoni[1], Massimiliano Dapporto[1], Laura Mercatali[2], Alessandro De Vita[2], Anna Tampieri[1], Michele Iafisco[1], Simone Sprio[1]
*[1]Institute of Science, Technology and Sustainability for Ceramic Materials Development – National Research Council of Italy (ISSMC-CNR), Faenza, Italy, [2]Osteoncology and Rare Tumors Center, Istituto Scientifico Romagnolo per lo Studio e la Cura dei Tumori, Meldola, Italy*

**15.00 – 15.15 Synthesis and Rheological Evaluations of Ion-Doped Calcium Phosphate-Based Bioceramic for Bone Regeneration**
Zahid Abbas[1,2], Massimiliano Dapporto[1], Anna Tampieri[1], Simone Sprio[1]
*[1]Istituto di Scienza, Tecnologia e Sostenibilità per lo Sviluppo dei Materiali Ceramici-Consiglio Nazionale Delle Ricerche (ISSMC-CNR), 48018 Faenza, Italy, [2]University of Bologna, 40126 Bologna, Italy*

**15.15 – 15.30 In Vitro Cytotoxicity of Dental Composites: A Systematic Review**
Bota Sergiu-David[1], Chețe Sofia[1], Negruț Daria[1], Moldovan Ioana[1], Lăcătușu Răzvan[1], Mate Diana-Denisa[1], Meda Lavinia Negruțiu[1,2], Romînu Mihai[1,2], Cîrligeriu Laura Elena[1], Sinescu Cosmin[1,2]
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**15.30 – 15.45 Cartilage regeneration: innovative molecules and systems to improve healing and counteract arthritis**
Scalia, A.C.[1], Bonifacio, M.A.[2], Cochis, A.[1], Cometa, S.[3], Scalzone, A.[4], Gentile, P.[4], Procino, G.[5], Milano, S.[5], De Giglio, E[2], Rimondini, L[1].
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**15.45 – 16.00 Break**

## 16.00 – 18.00 4th Session – Theoretical Modeling of Materials
## Chairpersons: Dr. Marko Opačić and Iva Toković

**16.00 – 16.15 $LaMnO_3$ thin films: Experimental study and a DFT calculation**
Iva Toković[1], Danica Piper[1], Jelena Vukmirović[1], Sara Joksović[2], Jovana Stanojev[2], Branimir Bajac[2], Marija Milanović[1], Stevan Armaković[3], Vladimir Srdić[1]
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**16.15 – 16.30 Influence of layer thickness and external bias variation on intersubband absorption in n-doped $BaSnO_3$ symmetric quantum wells**
Novak Stanojević[1], Jelena Radovanović[1,2], Nikola Vuković[1,2]
*[1]University of Belgrade, School of Electrical Engineering, Bulevar kralja Aleksandra 73, 11120 Belgrade, Serbia, [2]Centre for light-based research and technologies COHERENCE, Belgrade, Serbia*

**16.30 – 16.45 Role of halogen substituents in the design of halogen-containing high-energy materials**
Aleksandra B. Đunović[1], Ivana S. Veljković[2], Vanja Šajatović[3], Dušan Ž. Veljković[3]
*[1]Innovation Center of the Faculty of Chemistry, Belgrade, Serbia, [2]Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Belgrade, Serbia, [3]University of Belgrade - Faculty of Chemistry, Belgrade, Serbia*

**16.45 – 17.00 Tris-(nitroacetylacetonato) complexes as new high-energy materials**
Danijela S. Kretić[1], Ivana S. Veljković[2], Nikola Marković[1], Dušan Ž. Veljković[1]
*[1]University of Belgrade-Faculty of Chemistry, Studentski trg 12-16, 11000 Belgrade, Serbia; [2]University of Belgrade-Institute of Chemistry, Technology and Metallurgy, Department of Chemistry, Njegoševa 12, 11000 Belgrade, Serbia*

**17.00 – 17.15 Molecular modeling of selected methylimidazolium ionic liquids using GROMACS simulation software**
Ivona Đorđević[1], Milana Zarić[2], Ivona Radović[1]
*[1]University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, 11120 Belgrade, Serbia, [2]University of Belgrade, Institute of Chemistry, Technology, and Metallurgy-National Institute of Republic of Serbia, Njegoševa 12, 11000 Belgrade, Serbia*

**17.15 – 17.30 The Effects of Alloying Elements on Mechanical Properties of NIOMOL 490K steel**

Ana Maksimovic[1], Ljubica Milovic[2], Bojana Zecevic[1], Branislav Djordjevic[3], Vujadin Aleksic[4]
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**17.30 – 17.45 Characterization of fracture behavior of a low carbon microalloyed steel for elevated temperature application**

Bojana Zečević[1], Ana Maksimović[1], Ljubica Milović[2], Vujadin Aleksić[3], Srđan Bulatović[3]
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**17.45 – 18.00 Calibration of Discrete Element Method Parameters to Simulate a Planetary Ball Mill**

Mohsen Mhadhbi
*Laboratory of Useful Materials, National Institute of Research and Physicochemical Analysis, Technopole Sidi Thabet 2020 Ariana, Tunisia*

## Thursday, December 1, 2022

## 09.00 – 10.45 5th Session – Nanostructured Materials I
## Chairpersons: Dr. Vuk Radmilović and Jelena Rmuš

**09.00 – 09.15 High-temperature tribological testing of magnetron sputtered nanolayered TiAlN/TiSiN coating deposited on tool steel**

Vladimir Terek[1], Lazar Kovačević[1], Peter Panjan[2], Zoran Bobić[1], Aljaž Drnovšek[2], Branko Škorić[1], Pal Terek[1]
*[1]University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia, [2]Jožef Stefan Institute, Ljubljana, Slovenia*

**09.15 – 09.30 The role of copper doping on physicochemical properties of bismuth vanadate**

Marko Jelić[1], Igor Pašti[2], Bojana Nedić Vasiljević[2], Jelena Erčić[1], Danica Bajuk-Bogdanović[2], Zoran Jovanović[1], Sonja Jovanović[1]
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**09.30 – 09.45 Mechanochemically modified composites of molybdenum disulfide and graphene oxide for hydrogen evolution reaction**

Jelena Rmuš[1], Blaž Belec[2], Željko Mravik[1], Sara Mijaković[1], Zoran Jovanović[1], Ivana Stojković Simatović[3], Sandra Kurko[1]

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**09.45 – 10.00 Investigation of Dissolution and Redeposition Mechanisms of High Surface Area Carbon Supported Pt alloys for Oxygen Reduction Reaction in Low Temperature Proton Exchange Membrane Fuel Cells**

Armin Hrnjić[1,2], Ana-Rebeka Kamšek[1], Andraž Pavlišič[3], Fransicso Ruiz-Zapeda[1], Matija Gatalo[1], Leonard Moriau[1], Primož Jovanovič[1], Nejc Hodnik[1,2]

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**10.00 – 10.15 Electrochemically-grown chloride-free $Cu_2O$ nanocubes favorably electroreduce $CO_2$ to methane**: **The interplay of appropriate electrochemical protocol**

Stefan Popović[1,2], Mohammed Azeezulla Nazrulla[1], Primož Šket[3], Khaja Mohaideen Kamal[4], Blaž Likozar[4], Luka Suhadolnik[5], Luka Pavko[1], Angelija Kjara Surca[1], Marjan Bele[1], Nejc Hodnik[1,2]

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**10.15 – 10.30 Lithium-ion insertion into anatase $TiO_2$ nanotube arrays at room temperature**

Nemanja Latas[1,2], Nikola Cvjetićanin[1], Vladimir Rajić[2]

*[1]University of Belgrade - Faculty of Physical Chemistry, Studentski Trg 12-16, 11158 Belgrade, Serbia, [2]University of Belgrade - Department of Atomic Physics, INS Vinča – National Institute of the Republic of Serbia, Mike Alasa 12-14, 11001 Belgrade, Serbia*

**10.30 – 10.45 Tuning the Stability of Graphene Derived Carbon Support in Polymer Electrolyte Membrane Fuel Cell Electrocatalysts**

Luka Pavko[1], Matija Gatalo[1], Francisco Ruiz-Zepeda[1], Matjaž Finšgar[2], Nejc Hodnik[1], Boštjan Genorio[3], Miran Gaberšček[1]

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**10.45 – 11.00 Break**

## 11.00 – 12.45 6th Session – Nanostructured Materials II
## Chairpersons: Dr. Nadica Abazović and Željko Mravik

**11.00 – 11.15 Galvanostatic charge/discharge of thermally treated and ion-beam irradiated graphene oxide/12-tungstophosphoric acid nanocomposites**

Željko Mravik[1], Jelena Rmuš[1], Blaž Belec[2], Andrzej Olejniczak[3,4], Nikita Kirilkin[3], Nemanja Gavrilov[5], Vladimir Skuratov[3], Zoran Jovanović[1]

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**11.15 – 11.30 Determination of electrochemically active surface area of Ir-based catalysts for oxygen evolution reaction**

Anja Lončar[1,2], Primož Jovanovič[1], Nejc Hodnik[1,2], Miran Gaberšček[1,3]

*[1]Department of Materials Chemistry, National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia, [2]University of Nova Gorica, Vipavska 13, SI-5000 Nova Gorica, Slovenia, [3]Faculty of Chemistry and Chemical Technology, University of Ljubljana, Večna pot 113, SI-1000 Ljubljana, Ljubljana*

**11.30 – 11.45 Atomically resolved structural changes of TiON-supported Ir oxygen evolution reaction catalyst**

Ana Rebeka Kamšek[1,2], Anja Lončar[1,3], Gorazd Koderman Podboršek[1,4], Marjan Bele[1], Luka Suhadolnik[5], Primož Jovanovič[1], Nejc Hodnik[1,3,4]

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**11.45 – 12.00 The biocorrosion activity of ZnO-based materials as biosensors**
Katarina Aleksić[1], Ana Stanković[1], Ljiljana Veselinović[1], Ivana Stojković Simatović[2], Smilja Marković[1]
*[1]Institute of Technical Sciences of SASA, Belgrade, Serbia, [2]University of Belgrade, Faculty of Physical Chemistry, Belgrade, Serbia*

**12.00 – 12.15 Taming the morphology of ZnO nanomaterials with chemistry**
Zorica Novakovic[1], Snežana, Papović[1], Marko Radović[2], Branimir Bajac[2]
*[1]University of Novi Sad, Faculty of Sciences, Novi Sad, Republic of Serbia, [2]University of Novi Sad, BioSense Institute, Novi Sad, Republic of Serbia*

**12.15 – 12.30 Mechanical Properties of Jute/nano-$ZrO_2$ Composite Laminates**
Jelena D. Gržetić, Slavko Mijatov, Marica Bogosavljević, Tihomir Kovačević, Saša Brzić, Danica M. Bajić
*Military Technical Institute, Ratka Resanovića 1, Belgrade, Serbia*

**12.30 – 12.45 Effect of disorder and electron-phonon interaction on 2*H*-$TaSe_{2-x}S_x$ lattice dynamics probed by Raman spectroscopy**
Jovan Blagojević[1], Sanja Đurđić Mijin[1], Jonas Bekaert[2], Milorad Milošević[2], Čedomir Petrović[3], Yu Liu[3], Marko Opačić[1], Zoran Popović[1, 4] and Nenad Lazarević[1]
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**12.45 – 13.45 Lunch break**

## 13.45 – 15.30 7th Session – Nanostructured Materials III
## Chairpersons: Dr. Sonja Jovanović and Tea Belojica

**13.45 – 14.00 Crystal structure of $InSiTe_3$ studied by Raman spectroscopy**
Ana Milosavljević[1], Sanja Đurđić[1], Tea Belojica[1], Andrijana Šolajić[1], Jelena Pešić[1], Bojana Višić[1], Yu Liu[2], Cedomir Petrovic[2], Zoran V. Popović[1,3], Nenad Lazarević[1]
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**14.00 – 14.15 Optical properties of nanostructured multi-stoichiometric tungsten suboxides**
Bojana Višić[1,2,3], Luka Pirker[1,3], Marko Opačić[2], Ana Milosavljević[2], Nenad Lazarević[2], Boris Majaron[3,4], Maja Remškar[1]
*[1]Department of Condensed Matter Physics, Jozef Stefan Institute, Jamova Cesta 39, 1000 Ljubljana, Slovenia, [2]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia, [3]Department of Complex Matter, Jozef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia, [4]Faculty of Physics and Mathematics, University of Ljubljana, Jadranska 19, Slovenia*

**14.15 – 14.30 Development of Self-assembling Bioactive Hydroxyapatite Nanorods**
Federico Pupilli[1,2], Andrea Ruffini[1], Anna Tampieri[1], Simone Sprio[1]
*[1]Institute of Science, Technology and Sustainability for Ceramic Materials, Development – National Research Council of Italy (ISSMC-CNR), Faenza, Italy, [2]University of Padua, Italy*

**14.30 – 14.45 Chitosan-stabilized magnetic nanoparticles for application in medicine**
I. Khmara[1], O. Strbak[2], M. Molcan[1], A. Antosova[1], Z. Gazova[1], M. Kubovcikova[1], I. Antal[1], V. Zavisova[1], M. Koneracka[1]
*[1]Institute of Experimental Physics, SAS, Watsonova 47, Kosice, Slovakia, [2]Biomedical Center Martin, JFM CU, Mala Hora 4, 03601 Martin, Slovakia*

**14.45 – 15.00 Nanostructured $TiO_2$@$SiO_2$@$FeO_x$: Application in photocatalysis**
Filip Koldžić, Aleksandra Dapčević
*University of Belgrade – Faculty of Technology and Metallurgy, Serbia*

**15.00 – 15.15 Thermo-physical properties of epoxy resin reinforced by single-walled and multi-walled carbon nanotubes**
Illia Zhydenko[1,2], Dmytro Chalyy[1], Halyna Klym[2,3], Ivan Karbovnyk[2,3]
*[1]Lviv State University of Life Safety, Lviv, Ukraine, [2]Lviv Polytechnic National University, Lviv, Ukraine, [3]Ivan Franko National University of Lviv, Lviv, Ukraine*

**15.15 – 15.30 Free-volume transformation in the $BaGa_2O_4$ ceramics caused by $Eu^{3+}$ Ions**
Halyna Klym[1,2], Yuriy Kostiv[1]
*[1]Lviv Polytechnic National University, Lviv, Ukraine, [2]Ivan Franko National University of Lviv, Lviv, Ukraine*

**15.30 – 16.00 Break**

## 16.00 – 17.45 8th Session – Materials for New Generation Solar Cells and New Synthesis and Processing Methods
## Chairpersons: Dr. Smilja Marković and Jovan N. Lukić

**16.00 – 16.15 Thin Film Polyaniline/Silver Nanowires Nanocomposites for Optoelectronic Applications**
Jovan N. Lukic, Vuk V. Radmilovic
*Faculty of Technology and Metallurgy, University of Belgrade, Serbia*

**16.15 – 16.30 Solar cells for window applications**
Branislav Milenković[1], Đorđe Jovanović[2], Mladen Krstić[3]
*[1]Faculty of Applied Science, DušanaPopovića 22a, 18000, Niš, Department of Mechanical Engineering, [2]Mathematical institute of SASA, Kneza Mihaila 36, 11000, Belgrade, Department of Computer Science, [3]Faculty of Mechanical and Civil Engineering, Dositejeva 19, 36000, Kraljevo, Department of Mechanical Engineering*

**16.30 – 16.45 Innovative nondestructive optical method for plant overall health evaluation**
Katarina M. Miletić[1], Miloš S. Mošić[1], Marijana Milutinović[2], Nikola Šušić[3], Vidoje B. Kasalica[4]
*Faculty of Physics[1], Faculty of Forestry[2], Institute for Multidisciplinary Research[3], Faculty of Mechanical Engineering[4], University of Belgrade, Belgrade, Serbia*

**16.45 – 17.00 32Si Geochronometer: Radiochemical separation and purification of 32Si for half-life redetermination**
Đorđe Cvjetinović[1,2], Mario Veicht[1,3], Ionut Mihalcea[1], Dorothea Schumann[1]
*[1]Laboratory of Radiochemistry, Paul Scherrer Institut Villigen, Switzerland, [2]Faculty of Physical Chemistry, University of Belgrade, Belgrade, Serbia, [3]École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland*

**17.00 – 17.15 Early and non-invasive diagnosis of malignant and premalignant lesions of the mucosa of the oral cavity through imagistic methods**
Daria Negrut[1,2], Pricop Marius[1,2], Emanuela-Lidia Craciunescu[1,2], Sergiu Chebici[1,2], Ioana Moldovan[1,2], Meda Lavinia Negrutiu[1,2], Mihai Rominu[1,2], Virgil-Florin Duma[3,4], Cosmin Sinescu[1,2]
*[1]Universitatea de Medicina si Farmacie "Victor Babes", Facultatea de Medicina Dentara, Timisoara, Romania, [2]Research Center in Dental Medicine Using Conventional and Alternative Technologies, School of Dental Medicine, "Victor Babes" University of Medicine and Pharmacy of Timisoara, 9 Revolutiei 1989 Ave., 300070 Timisoara, Romania, [3]Doctoral School, Polytechnic University of Timisoara, 1 Mihai Viteazu Ave., 300222 Timisoara, Romania, [4]3OM Optomechatronics Group, Aurel Vlaicu University of Arad, 77 Revolutiei Ave., 310130 Arad, Romania*

**17.15 – 17.30 Photography in dentistry- a new approach**

Ioana Moldovan[1,2], Emanuela-Lidia Craciunescu[1,2], Sergiu Chebici[1,2], Daria Negrut[1,2], Meda Lavinia Negrutiu[1,2], Virgil-Florin Duma[3,4], Mihai Rominu[1,2], Pricop Marius[1,2], Cosmin Sinescu[1,2]

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**17.30 – 17.45 New Concept in Luting Zirconia Crowns**

Chete Sofia[1.2], Novac Andreea Codruta[1.2], Neagu Carina Sonia[1.2], Pop Daniela Maria[1.2], Craciunescu Emanuela[1.2], Rominu Mihai[1.2], Negrutiu Meda Lavinia[1.2], Moldovan Ioana[1.2], Negrut Daria[1.2], Serban Christa[1.2], Duma Virgil Florin[2.3.4], Sinescu Cosmin[1.2]

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## Friday, December 2, 2022

## 09.00 – 11.00 9th Session – Materials for High-technology Application I
## Chairpersons: Dr. Dragana Jugović and Sina Kavak

**09.00 – 09.15 Electrodeposition of Ni-Sn alloys on porous Ni substrates as Hydrogen evolution catalysts**

J. Gojgic[1], A. Petricevic[1], M. Krstajic Pajic[1], T. Rauscher[2], C.I. Bernaecker[2], V. Jovic[3]

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**09.15 – 09.30 Satellite Structured Boride Reinforced In718 Based Composite Powder Preparation for Additive Manufacturing**

Sina Kavak[1,2], Emre Tekoğlu[3], M. Lütfi Öveçoğlu[1], Duygu Ağaoğulları[1,2]
*[1]Istanbul Technical University, Faculty of Chemical and Metallurgical Engineering, Department of Metallurgical and Materials Engineering, Particulate Materials Laboratories (PML), Graphene & 2D Materials Laboratory, 34469 Maslak, Istanbul, Türkiye, [2]Istanbul Technical University, Prof. Dr. Adnan Tekin Materials Science and Production Technologies Applied Research Center (ATARC), 34469 Maslak, Istanbul, Türkiye, [3]Department of Nuclear Science and Engineering, Massachusetts Institute of Technology, Cambridge, 02139, USA*

**09.30 – 09.45 Composite coatings based on Zn-Co alloy and yttrium/samarium with the self-healing effect of substrate**

Aleksandra Mijatović, Jelena Bajat
*Department of Physical Chemistry and Electrochemistry, Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia*

**09.45 – 10.00 Influence of cold deformation on the hardness and electrical conductivity of the EN AW-7075 aluminum alloy**

Avram S. Kovačević, Uroš S. Stamenković
*University of Belgrade, Technical faculty Bor*

**10.00 – 10.15 Hybrid polymer composites epoxy/PVB reinforced with sub-micron and nano-sized BN**

Marijana Stalević[1], Milan Vučković[1], Bojana Fidanovski[1], Danica M. Bajić[1]
*Military Technical Institute, Ratka Resanovića 1, Belgrade, Serbia*

**10.15 – 10.30 Optimization Studies on Powder Preparation of SiC nanowire and SiC/$ZrB_2$ particulate reinforced In718 powders for additive manufacturing**

Sıddıka Mertdinç-Ülküseven[1,2], Sina Kavak[1,2], Emre Tekoğlu[3], İlayda Süzer[1,2], M. Lütfi Öveçoğlu[2], Duygu Ağaoğulları[1,2]
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**10.30 – 10.45 Infrared and Raman study of narrow-gap semiconductor $FeGa_3$**
C. Martin[1], V. A. Martinez[2], M. Opačić[3], S. Djurdjić-Mijin[3], P. Mitrić[3], A. Umićević[4], V. N. Ivanovski[4], A. Poudel[1], I. Sydoryk[1], Weijun Ren[5], R. M. Martin[6], D. B. Tanner[2], N. Lazarević[3], C. Petrovic[5], and D. Tanasković[3]
*[1]Ramapo College of New Jersey, Mahvah, NJ 07430, USA, [2]Department of Physics, University of Florida, Gainesville, Florida 32611, USA, [3]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia, [4]Vinca Institute of Nuclear Sciences – National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia, [5]Brookhaven National Laboratory, NY 11973, USA, [6]Montclair State University, Montclair, NJ 07043, USA*

**10.45 – 11.00 Applying electrically conductive hot melt copolyamide in the additive manufacturing process**
Michał Misiak[1], Kamil Majchrowicz[1], Karol Szlązak[1], Paulina Latko-Durałek[1,2]
*[1]Warsaw University of Technology, Faculty of Materials Science and Engineering, Woloska 141 Street, 02-507 Warsaw, Poland, [2]Technology Partners Foundation, Adolfa Pawinskiego 5A Street, 02-106 Warsaw, Poland*

**11.00 – 11.15 Break**

## 11.15 – 13.15 10th Session – Materials for High-technology Application II
## Chairpersons: Dr. Zoran Jovanović and Tamara Petrović

**11.15 – 11.30 Evaporation of polonium from LBE-cooled reactors**
Ivan Zivadinovic[1,2], Liu Lu[2], Patrick Steinegger[1,2], Jörg Neuhausen[2]
*[1]Laboratory of Radiochemistry, Nuclear Energy and Safety Division, Paul Scherrer Institute, Villigen PSI, Switzerland, [2]Laboratory of Inorganic Chemistry, Department of Chemistry and Applied Biosciences, ETH Zürich, Zürich, Switzerland*

**11.30 – 11.45 3D Electrodes for Industrial Alkaline Flow Electrolysers**
A. Petricevic[1], J. Gojgic[1], M. Krstajic Pajic[1], T. Rauscher[2], C.I. Bernaecker[2], V. Jovic[3]
*[1]University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, 11000 Belgrade, Serbia, [2]Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Branch Lab Dresden, Winterbergstraße 28, 01277 Dresden, Germany, [3]University of Belgrade, Institute for Multidisciplinary Research, Kneza Višeslava 1, 11030 Belgrade, Serbia*

**11.45 – 12.00 Hybrid aqueous Ca-ion battery: Design and Performance**
Tamara Petrović[1], Miloš Milović[2], Aleksandra Gezović[3], Jana Mišurović[3], Veselinka Grudić[3], Milica Vujković[1]
*[1]University of Belgrade - Faculty of Physical Chemistry, Belgrade, Serbia, [2]Institute of Technical Sciences of SASA, Belgrade, Serbia, [3]Faculty of Metallurgy and Technology, University of Montenegro, Podgorica, Montenegro*

**12.00 – 12.15 Epitaxial growth of metal oxide thin films on semiconductors**
Darija Petković, Zoran Jovanović
*Laboratory of Physics, Vinča Institute of Nuclear Sciences – National Institute of the Republic of Serbia, Belgrade, Serbia*

**12.15 – 12.30 PbSe targets for nuclear physics studies**
Nadine M. Chiera[1], Emilio Andrea Maugeri[1], Ivan Danilov[1], Javier Balibrea-Correa[2], Cesar Domingo-Pardo[2], Ulli Köster[3], Jorge Lerendegui-Marco[2], Mario Veicht[1], Ivan Zivadinovic[1], Dorothea Schumann[1]
*[1]Paul Scherrer Institute, Villigen PSI, Switzerland, [2]Instituto de Fisica Corpuscolar, Valencia, Spain, [3]Institut Laue-Langevin, Grenoble, France*

**12.30 – 12.45 Carbon felt/PPy-functionalized/AgCl composite as cathode material for rechargeble Mg cell**
Aleksandra S. Popović, Branimir N. Grgur
*University of Belgrade Faculty of Technology and Metallurgy Department of Physical chemistry and electrochemistry Karnegijeva 4, 11020 Belgrade, Serbia*

**12.45 – 13.00 Synthesis and Characterization of Al-x($Hf_{0.2}Ti_{0.2}Zr_{0.2}V_{0.2}Nb_{0.2}$)$B_2$ (x = 1, 2, 5, 10, 15 wt.%) Composites**
İlayda Süzer[1,2], A. Saruhan Tekinşen[1], Yunus Emre Özçakıcı[1], Sıddıka Mertdin[3]-Ülküseven[1,2], Kübra Gürcan Bayrak[3], Erhan Ayas[3], M. Lütfi Öveçoğlu[1], Duygu Ağaoğulları[1,2]
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**13.00 – 13.15 Screening for novel bioconverters of animal husbandry wastes into valuable substances**
Anna Shestakova[1,2], Elizaveta Popova[1], Alexander Osmolovskiy[1]
*[1]Department of Microbiology, Faculty of Biology, Lomonosov Moscow State University; Russia, 119234, Moscow, Leninskie gory, 1, building 12, [2]Faculty of Biology and Biotechnology, HSE University; Russia 101000, Moscow, st. Myasnitskaya, 20.*

**13.15 – 14.15 Lunch break**

## 14.15 – 16.15 11th Session – Environmental Materials I
## Chairpersons: Dr. Ljiljana Damjanović-Vasilić and Jana Petrović

**14.15 – 14.30 Heterojunctions based on g-$C_3N_4$ for the photocatalytic reduction of Cr(VI)**
Jana Petrović[1], Željko Radovanović[2], Slavica Lazarević[1], Đorđe Janaćković[1], Rada Petrović[1]
*[1]University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia, [2]Innovation Center of Faculty of Technology and Metallurgy, Ltd, Belgrade, Serbia*

**14.30 – 14.45 $TiO_2$ nanoparticles supported on natural zeolite clinoptilolite from Serbia for removal of bisphenol A from aqueous solution**
Srna Stojanović[1], Vladislav Rac[2], Kristina Mojsilović[3], Rastko Vasilić[3], Smilja Marković[4], Ljiljana Damjanović-Vasilić[1]
*[1]University of Belgrade-Faculty of Physical Chemistry, Studentski trg 12-16, P.O. Box 47, 11158 Belgrade 118, Serbia, [2]University of Belgrade-Faculty of Agriculture, Nemanjina 6, 11080 Belgrade, Serbia, [3]University of Belgrade-Faculty of Physics, Studentski trg 12-16, 11000 Belgrade, Serbia, [4]Institute of Technical Sciences of SASA, Knez Mihailova 35/IV, 11000 Belgrade, Serbia*

**14.45 – 15.00 Synthesis of biomorphic $TiO_2$ and its photocatalytic activity in the removal of amitriptyline and ciprofloxacin from the aqueous medium**
Dušica Jovanović[1], Marko Radović[2], Daniela Šojić Merkulov[1], Szabolcs Bognár[1], Nina Finčur[1]
*[1]University of Novi Sad Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg D. Obradovića 3, 21000 Novi Sad, Serbia, [2]BioSense Institute, Dr Zorana Đinđića 1, 21000 Novi Sad, Serbia*

**15.00 – 15.15 Modified food wastes as potential sorbents for phosphate removal**
Anja Antanasković[1], Zorica Lopičić[1], Tatjana Šoštarić[1], Jelena Milojković[1], Vladimir Adamović[1], Danijela Smiljanić[2], Milan Milivojević[2]
*[1]Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, Serbia, [2]Faculty of Technology and Metallurgy, University of Belgrade, Serbia*

**15.15 – 15.30 Sustainable removal of 17α-ethynilestradiol from aqueous environment, using newly synthesized ZnO-based nanocomposites**
Szabolcs Bognár[1], Tamara Ivetić[2], Nina Finčur[1], Dušica Jovanović[1], Daniela Šojić Merkulov[1]
*[1]University of Novi Sad Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection, Trg Dositeja Obradovića 3, 21 000 Novi Sad, Serbia, [2]University of Novi Sad Faculty of Sciences, Department of Physics, Trg Dositeja Obradovića 4, 21 000 Novi Sad, Serbia*

**15.30 – 15.45 Onion peels as an adsorbent for copper ions biosorption – Kinetic and thermodynamic studies**
Miljan Marković, Milan Gorgievski, Nada Štrbac, Vesna Grekulović, Kristina Božinović, Milica Zdravković, Marina Marković
*University of Belgrade, Technical Faculty in Bor, Bor, Serbia*

**15.45 – 16.00 Ultra-high performance fiber reinforced concrete for applications in complex building structures**
Bojana Grujić, Žarko Grujić
*University of Banja Luka, Faculty of Architecture, Civil Engineering and Geodesy, Banja Luka /Department of Civil Engineering*

**16.00 – 16.15 Decolorization of azo dye Methyl Orange with crude fungal laccase obtained by growing *Ganoderma spp.* on cereal mix**
Nevena Ilić[1], Marija Milić[2], Slađana Davidović[2], Anđela Kostić[2], Katarina Mihajlovski[2], Suzana Dimitrijević-Branković[2]
*[1]University of Belgrade, Innovation Center of Faculty of Technology and Metallurgy, Belgrade, Serbia, [2]University of Belgrade, Faculty of Technology and Metallurgy, Department for Biochemical Engineering and Biotechnology, Belgrade, Serbia*

**16.15 – 16.30 Break**

## 16.30 – 18.00 12th Session – Environmental Materials II
## Chairpersons: Dr. Ana Stanković and Aleksandra Medić

**16.30 – 16.45 Pyrimethanil cytotoxic activity on human testicular teratocarcinoma NT2/D1 cells**
Aleksandra Medić[1], Danijela Stanisavljević Ninković[1], Andrijana Lazić[1], Milena Aleksić[2], Marija Schwirtlich[1], Perica Vasiljević[2], Isidora Petrović[1], Milena Stevanović[1,3,4]
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**16.45 – 17.00 An assessment of tritium deposition on the earth's surface**
Emina Tursunović[1], Marija Janković[2], Marko Daković[1], Nataša Sarap[2], Jelena Krneta Nikolić[2], Milica Rajačić[2], Ivana Vukanac[2]
*[1]University of Belgrade, Faculty of Physical Chemistry, Studentski trg 12-16, 11000 Belgrade, [2]University of Belgrade, Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, Radiation and Environmental Protection Department, Mike Petrovića Alasa 12-14, 11001 Belgrade*

**17.00 – 17.15 Ultrasound procedures for improved protein extraction from pumpkin leaves Cucurbita pepo**
Gavrilo Mihajlović[1], Zorica Knežević-Jugović[1]
*University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, 11120 Belgrade, Serbia*

**17.15 – 17.30 Characterization of the historical glass sampless**
Marija Kovač, Bojan Miljević, Mihajlo Valuh, Snežana Vučetić
*University of Novi Sad – Faculty of Technology, Laboratory for Materials in Cultural Heritage (HERITAGELAB), Bulevar cara Lazara 1, 21000, Novi Sad, Serbia*

**17.30 – 17.45 Quality control of HPGe detectors for gamma spectrometry of environmental samples**
Jelena Krneta Nikolić, Milica Rajačić, Ivana Vukanac, Nataša Sarap, Marija Janković
*Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, Mike Petrovića Alasa 12-14, Belgrade*

**17.45 – 18.00 Employing EFM as a nondestructive method for studying green corrosion inhibition of copper in chloride environment**
Milica Zdravković[1], Vesna Grekulović[1], Nada Štrbac[1], Milan Gorgievski[1], Edina Huseinović[2], Miljan Marković[1], Kristina Božinović[1]
*[1]University of Belgrade, Technical Faculty in Bor, Bor, Serbia, [2]University of Tuzla, Faculty of Natural Sciences and Mathematics, Tuzla, Bosnia and Herzegovina*

## 18.10 Closing Ceremony

1-1

**Evaluation of cytotoxic and hemostatic effects of polymethylmethacrylate, polymethylmethacrylate enriched with chitosan and polymethylmethacrylate enriched with silver chloride**

Nemanja Mladenović[1], Milena Kostić[2], Nikola Gligorijević[2], Ljubiša Nikolić[3], Perica Vasiljević[1]

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One of the most common problems in dental prosthetics are frequent infections, which occur as a result of wearing a prosthesis due to the retention of food particles between the prosthesis and the mucous membrane of the jaw. To overcome this problem, many acrylic biometers, esters of polyacrylic acid, are nowadays enriched with antimicrobial agents. The most commonly used acrylate in prosthetics is polymethyl methacrylate (PMMA) synthesized by polymerization of methyl methacrylate with the addition of free radicals. The aim of this work was to evaluate the potential cytotoxic and hemostatic effects of two newly synthesized PMMA enriched with chitosan and silver chloride nanoparticles (5, 10, and 20%), while PMMA was used as the control material. Cytotoxicity was evaluated using RBC hemolytic test and MTT assay on HeLa and MRC5 cell lines. Hemostatic effect was assessed using the prothrombin time test. According to the results of the RBCs hemolysis and MTT experiment, none of the tested materials did show any significant cytotoxicity. However, tested extracts did cause a slight hemostatic imbalance in terms of accelerating the coagulation, where the highest coagulation was induced by 20% AgCl enriched PMMA, i.e., 25.3% compared with negative control. To conclude, tested biomaterials showed high biocompatibility in *in vitro* conditions. However, more studies are needed before the possible future usage of these materials as antimicrobial ones for the production of dental prostheses and supports for dental prostheses.

1-2

## Synthesis and characterization of dental inserts based on calcium-phosphate, doped with magnesium, strontium and fluorine ions

Jelena Stanisavljević[1], Tamara Matić[2], Zvezdana Baščarević[3], Đorđe Veljović[1]
[1]*University of Belgrade – Faculty of Technology and Metallurgy, Belgrade, Serbia,*
[2]*University of Belgrade – Innovation Center of Faculty of Technology and Metallurgy, Serbia,* [3]*Institute for Multidisclipinary Research, University of Belgrade, Serbia*

Bioceramic materials based on calcium-hydroxyapatite (HAp), due to their bioactive properties, chemical composition, excellent biocompatibility and good mechanical properties play a very important role in the manufacture of implants for orthopedic, dentistry and maxillofacial surgery. After installation, dental inserts are in the central part of restauration of the teeth. It is necessary to synthesize a biocompatible material that would find application in dentistry as a substitute for dentin. The aim of this work is to process, characterize and test the mechanical properties of synthesized dental inserts. Hydroxyapatite powder was synthesized and doped by hydrothermal method. The content of doped Mg and Sr ions in all cases was 3 mol. % related to calcium, while the content of F ions in the powders were 0.5, 1 and 2 mol. %. Energy dispersive spectroscopy confirmed the proportion of doped F ions in the synthesized powders was 0, 0.24 and 1.34 at. %, respectively. The Ca/P molar ratio in the powders was 1.16, 1.17 and 1.18 respectively, which indicates calcium-deficient powders. The inserts were pressed with a uniaxial press at 100 MPa and further by isostatic press at 400MPa and sintered at 1200 °C for 2 hours. X-ray diffraction analysis of the sintered materials showed the presence of both, HAp and β-tricalcium phosphate. Scanning electron microscopy was used to examine the microstructure of controlled porous inserts and the morphology of nanostructured powders. Particles have similar dimensions and needle structure. While examining the microstructure of the inserts, it was noticed that increasing in the amount of F ions, affected the increase in the number and size of micron sized pores, which was reflected on their mechanical properties. Examining the hardness and fractured toughness of the inserts, showed that with an increase in the proportion of F ions, the hardness of the inserts decreased, while the proportion of F ions has no significant effect on the fracture toughness. It was shown that fluoride ions have a significant effect on the properties of the obtained macroporous biomaterials, which indicate their potential for use in dentistry.

1-3

**A pH-sensor scaffold for mapping spatiotemporal gradients in three-dimensional in vitro tumour models**

Riccardo Rizzo[1], Valentina Onesto[1], Stefania Forciniti[1], Anil Chandra[1], Saumya Prasad[1], Helena Iuele[1], Francesco Colella[1,2], Giuseppe Gigli[1,2], Loretta L. Del Mercato[1]

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The detection of extracellular pH at single cell resolution is challenging and requires advanced sensibility. Sensing pH at high spatial and temporal resolution might provide crucial information in understanding the role of pH and its fluctuations in a wide range of physio-pathological cellular processes, including cancer. Here, a method to embed silica-based fluorescent pH sensors into alginate-based three-dimensional (3D) microgels tumour models, coupled with a computational method for fine data analysis, is presented. By means of confocal laser scanning microscopy, live-cell time-lapse imaging of 3D alginate microgels was performed and the extracellular pH metabolic variations were monitored in both in vitro 3D mono- and 3D co-cultures of tumour and stromal pancreatic cells. The results show that the extracellular pH is cell line-specific and time-dependent. Moreover, differences in pH were also detected between 3D monocultures versus 3D co-cultures, thus suggesting the existence of a metabolic crosstalk between tumour and stromal cells. In conclusion, the system has the potential to image multiple live cell types in a 3D environment and to decipher in real-time their pH metabolic interplay under controlled experimental conditions, thus being also a suitable platform for drug screening and personalized medicine.

1-4

## Mechanical properties and bioactivity of scaffolds based on calcium-phosphates doped with $Mg^{2+}$, $Sr^{2+}$ and $F^-$ ions and coated with chitosan

Teodora Jakovljević[1], Tamara Matić[1], Julijana Tadić[2], Đorđe Veljović[3]
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Human bones contain calcium-phosphate crystals as the main inorganic component. Small amounts of various cations and anions can be incorporated into hydroxyapatite (HAp) during synthesis and affect their microstructure, mechanical and biological properties mimicking the properties of normal biological tissues. The aim of this research was the synthesis and examination properties of bioceramic scaffolds based on Hap doped with strontium, magnesium and fluorine ions, uncoated and coated with polymer chitosan. The influence of dopedF ions and chitosan on the properties of bioceramic scaffolds was also investigated. HAp powders were synthesized and doped by hydrothermal process. The content of Mg and Sr doping ions was constant in amount of 3 mol. % related to calcium, while the content of F ions was 0.5, 1 and 2 mol. %. Powder with 1 mol. % F was calcined at a temperature of 1000 °C for 2 hours. The sponge replica method was used to obtain scaffolds. The scaffolds were subsequently coated with a thin layer of chitosan. The elemental analysis of the synthesized powders was determined by energy dispersive spectroscopy (EDS). EDS confirmed the presence of doping Mg and Sr, while the amount of doping F ions was 0, 0.24 and 1.34 at. %, respectively. X-ray diffraction analysis determined the phase composition of the powders and scaffolds, which showed the presence of HAp and additionally β-tricalcium phosphate phase in scaffolds. In the compressive strength (CS) test, the synthesized scaffolds had maximum CS of 14.6kPa, while the chitosan-coated scaffolds reached CS of 145.9 kPa. Bioactivity was investigated by keeping the scaffolds in simulated body fluid for28 days. Scanning electron microscopy was used to examine the morphology of nanostructured powders, microstructures of macroporous scaffolds and the bioactivity of the scaffolds. The uncoated scaffolds showed satisfactory bioactivity. Lower bioactivity occurred in coated scaffolds due to the slow degradation of the chitosan. It was observed that the addition of F ions and chitosan polymer resulted in significant changes to the properties of the synthesized scaffolds, which indicates their potential application in tissue engineering and controlled drug release.

1-5

## Synthesis and characterization of composite resveratrol/selenium nanomaterial, and preliminary assessment of its' antioxidative effect and biocompatibility

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Natural chemicals and earth elements are increasingly used in research as basis for novel materials intended for use in medicine. Among phytopharmaceuticals, more specifically polyphenols, resveratrol is known for its' antioxidative, anticancer, antimicrobial, and other beneficial effects. Selenium, an essential trace element, is lately being recognized in nanoparticle form as less toxic and equally or more efficient than commercially available forms. The synergy of these two agents have not been shown until lately, when their synergistic antioxidative and gene expression effects were investigated for the purpose of treating Alcheimer disease. During our previous research, we have successfully synthesized pure resveratrol particles, as well as selenium nanoparticles (SeNPs). Both of them were separately investigated regarding their biological activities. The first step in evaluation of their possible synergistic antioxidative effect was obtaining the stable composite of these two materials. Synthesis parameters and processing methods were varied, and obtained suspensions assessed by their macroscopic and microscopic characteristics. The sample with both components homogeneously distributed in the particle form, was chosen for further experiments. Ultraviolet-visible (UV-Vis) spectrophotometry and Fourier transform infrared spectroscopy (FTIR) were used to characterize sample, and antioxidative activity (by DPPH reduction assay), and cytocompatibility (using MTT cytotoxicity assay) were additionally determined. Results showed improved cytocompatibility as compared to pure resveratrol particles, and preserved, significantly high antioxidative potential.

1-6

**Stability of phospholipid liposomes with encapsulated *Rosa canina* L. seed oil**

Natalija Čutović[1], Jelena Živković[1], Katarina Šavikin[1], Branko Bugarski[2], Aleksandar Marinković[2], Danica Ćujić[3], Aleksandra A. Jovanović[3]

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In the present study, phospholipid liposomes with encapsulated *Rosa canina* L. seed oil were developed using the proliposome method. Particle size, polydispersity index (PDI), zeta potential, conductivity, and mobility of the obtained liposomes were monitored for 60 days. Particle size measured immediately after the liposomal preparation was 509.3±13.2 nm, while PDI was 0.280±0.015. Zeta potential, conductivity, and mobility determined immediately after the preparation of liposomes were -27.3±2.3 mV, 0.024±0.005 mS/cm, and -2.14±0.18 μmcm/Vs, respectively. The vesicle sizes of oil-loaded liposomes changed significantly after the 21$^{st}$ day of storage (became smaller), while statistically significant changes in PDI values were not noticed. The zeta potential (as a measurement of liposomal stability) and mobility did not vary in the liposomal population, but the conductivity of the liposomes statistically significantly decreased during the 60-day stability study. The beneficial effects of active compounds from *R. canina* seed oil on human skin, highlight the use of stable oil-loaded liposomes for potential application in pharmaceutical and cosmetic industries.

1-7

**Encapsulation of nutrients using proteins derived from leaves**

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Various encapsulation techniques are utilized for maintaining the stable structure and function of nutrients while they pass through the gastrointestinal tract (GI). Using proteins as encapsulation agents have been proven beneficial given their high nutritional quality and ability to form various nanostructures (nanoparticles, nanofibres, hydrogels...). Proteins derived from plants can be largely exploited for this cause. Ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCO) is the most abundant protein in the world. It is found in every plant and due to biodegradability, digestibility, and high nutrient count it has a great potential for nutrient encapsulation. Since RuBisCO is identified in every part of the plant, waste biomass can be utilized as a source of it. This study investigated the potential use of RuBisCO derived from pumpkin leaves as an encapsulation agent for folic acid. White protein RuBisCO fraction was isolated from pumpkin leaf juice using acidic precipitation (pH 4.5) and was lyophilized. Calcium ions ($Ca^{2+}$) were used as a binder to form nanoparticles. The preparation procedure of nanoparticles was optimized by testing different protein concentrations, concentrations of Ca2+, and pH levels. Obtained nanoparticles were characterized in terms of size distribution, average size, and stability. They have shown high stability after seven days without any prominent change in zeta potential and size of particles. Nanoparticles that have shown the highest stability and uniform distribution were then used for efficient encapsulation of folic acid. A kinetic study of the controlled release of nutrients in simulated GI was performed and extended nutrient release was observed.

2-1

**Development of a physiologically relevant osteosarcoma model based on alginate scaffolds and perfusion bioreactor**

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Finding a cure for cancer is one of the greatest challenges today and professionals from different areas are working together to overcome it. The lack of adequate model systems is one of the problems since experiments regarding cancer biology and drug testing are mainly conducted on cells in monolayers, followed by animal studies. There is a huge gap between the characteristics of these two model systems, and both systems fail to mimic diseased human tissue completely. A proper model system should mimic *in vivo* diseased tissue, having a tridimensional structure and proper physiologically relevant mechanical and biochemical stimulation. In this work, the first steps were done to establish a model system for osteosarcoma, a tumor that is occurring in bone tissue. Regarding the bone nature, the model is based on a tridimensional porous scaffold composed of 1 wt% alginate and 1 wt% mineral powder β-TCP/hydroxyapatite in conjunction with a perfusion bioreactor. Murine osteosarcoma cells K7M2-wt were seeded onto the scaffolds and cultivated in the perfusion bioreactor for 7 days under the medium superficial flow velocity of 15 μm/s, while static cultures served as a control. After the cultivation period cells were metabolicly active and retained their proliferation ability, yet the scaffolds started to degrade under cultivation conditions. Porosity of scaffolds was analized in order to estimate hydrodynamic conditions which were affecting the cells. Calculated shear stress values were in the range 0.1 – 1 mPa, corresponding to those *in vivo*. The obtained results show the potential of the model system and indicate directions for system optimization in terms of cell seeding procedure and scaffold composition.

2-2

**Cellular self-assembly in a 3D osteosarcoma culture model based on alginate scaffolds and perfusion bioreactor**

Ivana Banićević[1], Ksenia Menshikh[2], Mia Radonjić[1], Jelena Petrović[1], Radmila Janković[3], Milena Milivojević[4], Milena Stevanović[4,5,6], Jasmina Stojkovska[1,7], Bojana Obradović[1]
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Osteosarcoma is an aggressive bone malignant disease with a high tendency for metastases. Stagnation in the patient survival rate in the last decades correlates to the lack of innovative solutions in anticancer drug development, which is still based on the use of cell monolayers and animal models. Intending to address this issue, our approach is to develop a physiologically relevant 3D*in vitro*osteosarcoma model that would truthfully reflect*in vivo*osteosarcoma cell microenvironment. Our model starts from single cell suspensions seeded onto improved macroporous composite alginate scaffolds (2 wt% alginate, 2 wt% hydroxyapatite) followed by cultivation in a perfusion bioreactor system. Murine osteosarcoma cells (K7M2-wt) were seeded at the density of $15x10^6$ cells per $cm^3$ of scaffold volume and cultivated for 7 days in perfusion bioreactors (3D Perfuse, Innovation Center of the Faculty of Technology and Metallurgy, Belgrade, Serbia) at the superficial medium velocity of 40 μm/s, while static cultures served as a control. Medium perfusion increased metabolic activity of the cells thus confirming beneficial effects of the enhanced mass transfer in the bioreactors. Additionally, histological analysis of scaffold cross-sections indicated that individual cells spontaneously formed spheroids during the cultivation under both static and perfusion conditions. Still, the spheroids formed in the latter case were more compact with increased amounts of extracellular matrix. Thus, the obtained results indicate potentials of the utilized 3D culture model to mimic the *in vivo* osteosarcoma cell microenvironment and potentially provide a tool for investigation of osteosarcoma cellular self-assembly and tumor development.

2-3

**Osteosarcoma *in vitro*: a step-by-step approach**

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The field of tumour engineering is undergoing rapid development thanks to the elaboration of biomaterials and dynamic culture systems aiming at developing reliable disease models suitable for drug testing and studying pathology mechanisms. The requirement of complex 3D microenvironments was brought by a strong need to set cancer cells into conditions closely mimicking the pathophysiological state on the tumour site, which would allow obtaining a plausible response to treatment due to the tumour-like behaviour of cells. The present study proposes a way to model osteosarcoma (OS) *in vitro* by utilizing a flow-perfused cell spheroid-seeded synthetic scaffold. The development of the above-proposed model is carried out in a stepwise approach based on using 2 types of OS cells (human U2OS and murine K7M2-wt), 2 types of scaffolds (freeze-dried composite alginate hydrogels with bioactive glass (BG) and with hydroxyapatite (HAp) particles) and perfusion bioreactors ("3D Perfuse", Innovation Center of FTM, Serbia). OS cell spheroids were obtained by culturing cells on the agarose-coated plates. The obtained spheroids suspended in collagen were seeded onto the HAp/alginate scaffolds and cultured up to 7 days under static and perfusion conditions (superficial velocity of 40 μm/s). A separate experimental study was set up in which alginate/BG scaffolds were seeded with human OS spheroids together with single-cell suspension of endothelial cells (ECs). Metabolic activity assay, as well as fluorescent microscopy, demonstrated sufficient viability of the tested cells cultured in the scaffolds under static conditions and formation of a network by ECs in the presence of OS spheroids. Perfusion culture studies, however, resulted in viable OS spheroids, but poorly integrated with the scaffolds. The proposed approach to modelling osteosarcoma *in vitro* may be considered promising showing certain physiologically relevant features (*e.g.*, OS-EC cell-cell interactions), although it needs further optimization in terms of cell infiltration (*i.e.*, scaffold porosity and pore size, as well as perfusion velocity).

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2-4

**Optimization of cell culture conditions for neural differentiation of NT2/D1 cells in alginate microfibers**

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Human pluripotent embryonal carcinoma NT2/D1 cell line respresents well established and widely used model system of human *in vitro* neurogenesis. 3D model systems mimic *in vivo* cell growth thus providing better insights into the human tissue dynamics during development. In order to study early phases of human neurogenesis in 3D model system we optimized condition for immobilisation of NT2/D1 cells in microalginate fibers, their propagation and induction of neural differentiation. We analyzed morphological characteristics, viability, proliferation and expression of specific markers of both, pluripotent NT2/D1 cells and retinoic acid induced NT2/D1 early neural progenitors. Our results indicate that the immobilization in microalginate fibers affected viability of NT2/D1 cells but did not impair the ability of surviving cells to adhere and proliferate. In obtained 3D system NT2/D1 cells preserved neural differentiation capacity upon induction with retinoic acid. Induction of NT2/D1 cells immobilized in microalginate fibers, by retinoic acid, represents exellent 3D model system for studying human neurogenesis and could be used as platform for screening the effects of drugs and bioactive compounds on initiation and progression of neural differentiation.

2-5

**Glucosomes: Magnetically induced controlled release of glucose modified liposomes**

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Novel methods of cancer therapy are constantly being investigated since the current approach heavily relies on the use of non-specific and toxic chemotherapy agents. Ideally, a drug used for cancer therapy would specifically target tumor sites or rather bind specifically with cancer cells. The way to achieve this is by targeting cancer cell specific receptors or receptors present in abnormally high counts at the surface. Rapid proliferation of cancer cells is fueled by large amounts of energy that is in turn produced by abnormal glucose uptake. Because of this high energy/glucose demand, cancer cells exhibit an abnormally high glucose receptor (GLUTs) count on their surface, compared to normal, healthy cells. We have utilized this glucose dependency to create glucose modified liposomes (Glucosomes) that are specifically bound by cancer cells. Glucosomes can be used to transport different substances, either hydrophilic or hydrophobic, and can therefore deliver any type of drug to cancer cells, increasing its efficiency. Another important aspect to consider is the controlled release of the drug being transported in order to maximize therapeutic efficiency. Controlled release can be achieved by utilizing different internal or external influences. In our study, we have used standard $Fe_3O_4$ magnetic nanoparticles to load glucosomes and induce their controlled opening via an external magnetic field. By applying an external magnetic field, the magnetic nanoparticles start heating up and transferring this thermal energy to the surrounding lipid bilayer, causing its perturbation and opening of the glucosome. Our study has found that controlled release can be achieved with high efficiency while the chemical stability of the $Fe_3O_4$ nanoparticles stays practically intact. Using EPR spectroscopy, we have shown that $Fe_3O_4$ nanoparticles remain trapped within the lipid bilayer and are essentially protected from oxidation that would diminish their magnetic properties. Since magnetic $Fe_3O_4$ nanoparticles are lodged well within the lipid bilayer no thermal damage can be caused to the drug being transported within the glucosome bilayer, making this a viable controlled release cancer targeting drug delivery system.

2-6

**Bioactives preservation of everlasting (*Helichrysum plicatum* L.) flowers extract by freeze drying method and powder characterisation**

Zorana Mutavski[1], Nada Ćujić Nikolić[1], Milica Radan[1], Dubravka Bigović[1], Smilja Marković[2], Katarina Šavikin[1]

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Everlasting flowers (*Helichrysum plicatum* L.), traditionally used for gastrointestinal disorders such as abdominal pain, jaundice, and hepatic disorders are a rich source of sensitive polyphenolic compounds whose preservation is of great importance. A critical point in the development of formulations with bioactive phenolic compounds, especially liquid extracts is their limited stability at elevated temperatures, pH variations, exposure to oxygen, light, and moisture. In order to overcome the extract limitations, drying method could be the optimal technique for preservation of bioactive compounds, in order to obtain stable powders with appropriate characteristics. One of the most advanced techniques based on the phenomenon of sublimation is a freeze drying, which enabling the long-term preservation of heat-sensitive compounds. In this study, extract obtained by percolation method was lyophilized by freeze drying method (firstly extract was frozen at -80 $^{o}$C for 1 h, then freeze-dried at -60 $^{o}$C with pressure of 0.011 mbar for 24 h, and finally main dried at -60 $^{o}$C with pressure of 0.0012 mbar, for an additional hour in order to remove the capillary water residues). The obtained freeze-dried extract (FHE) was characterized by drying efficiency, the contents of total polyphenols-TPC and flavonoids-TFC. The most dominant polyphenolic compounds were determined and quantified by HPLC method. Differential scanning calorimetry (DSC) and scanning electron microscopy (SEM) analyzes were also performed. The stability of individual compounds, quantified by the HPLC method, was investigated after 30 days, whereby the sample was exposed to a temperature of 40 °C. Drying efficiency was 94.68%, while TPC and TFC were 113.22 mg gallic acid/g and 28.16 mg catechin/g od FHE, respectively. The most dominant individual compounds were naringenin (22.47 mg/g) and kaempferol (21.47 mg/g) of FHE. The DSC method confirmed the FHE stability, and the SEM analysis confirmed that the extract was successfully encapsulated, without visible deformations. The obtained powder showed excellent stability in terms of the content of the dominant individual compounds, with increasing of their content after 30 days.

2-7

**Microencapsulation of Oregano and Thyme essential oils with hydroxypropyl-β-cyclodextrin**

Snežana Kuzmanović Nedeljković[1], Nada Ćujić Nikolić[1], Dubravka Bigović[1], Predrag Petrović[2], Dejan Pljevljakušić[1], Katarina Šavikin[1], Brankica Filipić[3]
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Among plant natural products, Oregano and Thyme essential oils (EOs) are well-known for their antimicrobial and antioxidant activity. The biological activities of EOs may be reduced due to oxidation and volatilization. Stability and preservation of EOs can be assured with the microencapsulation method based on complex coacervation technology. Cyclodextrins are suitable as carriers for volatile substances insoluble in water, and hydroxypropyl-β-cyclodextrin (HPCD) leads the group considering the aqueous solubility and safe toxicity profile. The aim of this study was to find conditions for preparing Oregano and Thyme EOs microencapsulates with the best technological properties.Oregano and Thyme EOs were encapsulated by the freeze drying (lyophilization) method. Nine different combinations were prepared, where HPCD content (10, 15 and 20%) and EO:HPCD mass ratio (1:1, 1:5 and 1:10) were varied. After stirring (200 rpm) for 24 h at a room temperature, suspensions were filtered through 0.45 mm PTFE filters. Samples were evaporated under vacuum and frozen (-80 °C for 1 h), then main drying was carried out (-60 °C, pressure of 0.011 mbar for 40 h), and final drying (-65 °C, pressure of 0.054 mbar for 1 h). To ensure the particle purity, lyophilizates were washed with acetonitrile and dried at 25 °C. The content of each EO was determined spectrophotometrically, encapsulation efficiency (EE%) and yield were calculated. Duncan's *post hoc* test was used to evaluate the differences between samples. The best conditions for both EOs were obtained with 15% HPCD and EO:HPCD mass ratio of 1:10. Yields of EOs for chosen Oregano and Thyme EOs complexes were 86.81 ± 2.20% and 89.83 ± 2.80%, respectively, with the following EE% of 49.08 ± 1.80% and 49.29 ± 0.18%. Microencapsulation is a promising method for improving the EOs stability profile, and these results could be very useful in the pharmaceutical and food industry for the implementation of new products.

3-1

**Bioactive hydroxyapatite/chitosan/poly(vinyl alcohol)/gentamicin composite coating electrodeposited on titanium**

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Titanium (Ti) is an implant material widely used in orthopedics due to its high corrosion resistance (naturally forms a passive oxide layer) and good mechanical properties. Although Ti has certain ability to osseointegrate, the biocompatibility and bioactivity of Ti can be significantly improved by modifying its surface. In order to improve antibacterial properties a broad spectrum antibiotic gentamicin was loaded in a composite coating of hydroxyapatite (HAP) with natural polymers chitosan (CS) and poly(vinyl alcohol (PVA) and was deposited on Ti using electrophoretic deposition (EPD) technique. EPD was carried out at the constant voltage on pure titanium plates from an aqueous suspension. Deposited HAP/CS/PVA and HAP/CS/PVA/Gent coating were characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), and field emission scanning electron microscopy (FE-SEM). The obtained results confirmed the formation of new composite coatings. Cytotoxicity against two types of cell lines (MRC-5 and L929) was investigated using trypan blue dye-exclusion test (DET) and MTT assay for assessing cell metabolic activity. The antibiotic loaded coating (HAP/CS/PVA/Gent) exhibited good antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*, while preserving low cytotoxicity, indicating the high potential for biomedical applications. Excellent osteogenic properties, through the promotion of osteoblast differentiation were confirmed by ALP assay. Results were much more pronounced for HAP/CS/PVA/Gent coating. Therefore, HAP/CS/PVA/Gent coating can be considered as an excellent promising candidate for biomedical hard tissue implants.

3-2

## Properties of Ti-O ALD films on $CN_x$ and nanolayer TiAlSiN PVD coatings intended for orthopedic implant applications

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Various coatings can be employed to increase corrosion resistance and biocompatibility of metallic materials that are used as material for orthopedic implants. Coating produced by physical vapor deposition (PVD) process commonly has excellent mechanical properties and low bioactivity unlike the Ti-O coating deposited by atomic layer deposition (ALD). A subsequent ALD deposition of Ti-O layer on PVD-coated substrates increases their corrosion resistance due to sealing of coating growth defect. Mechanical properties, particularly adhesion of the Ti-O layer on a PVD-coated surface, have a decisive influence on the application of this coating system. In this study, we examined properties of amorphous and anatase Ti-O layers deposited on TiAlN/$CN_x$ and TiAlN/TiSiN/nl-TiAlSiN PVD coatings. $CN_x$ and TiAlSiN coatings were deposited on surgical stainless steel (316L) by magnetron sputtering. On samples with PVD coatings a 50 nm thick Ti-O layers with different crystallography was deposited by ALD method. Surface topography was measured by tactile 3D profilometer and confocal microscopy. Adhesion was evaluated by qualitative indentation method. Scanning electron microscopy (SEM) and focused ion beam (FIB) was employed for analysis idents and coating defects. Surface topography analysis revealed that all groups have a similar surface roughness and that $CN_x$ coating has fewer coating growth defects. Cross sectional FIB analysis of defects revealed that ALD layers managed to fill the passages between the defects and coating layer for both investigated coatings. Adhesion of examined ALD layers is higher on TiAlSiN than on $CN_x$ coating which is probably due to the coating atom sizes and lattice mismatch. The anatase Ti-O layer has better adhesion on $CN_x$ and TiAlSiN coatings than the amorphous Ti-O. These results revealed that examined Ti-O layers could be successfully employed for sealing the PVD defects. The fact that amorphous Ti-O layer displays low adhesion and brittle behavior it is suggested that it is not suitable for application on orthopedic implants.

3-3

**Toward new therapies for the treatment of bone cancer: calcium phosphate-based cement as tuneable system for Doxorubicin delivery**

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Current therapy for the treatment of bone cancer involves the surgical removal of the affected bone and the systemic administration of high doses of anticancer drugs in order to achieve an effective drug concentration in bone tissue. However, the high drug concentration in the blood can induce serious side effects in other organs and tissues. Therefore, the development of devices that can combine the bone defect regeneration and, at the same time, deliver the effective drug dose to the bone tumour site without reaching toxic levels in the blood is an area of active research. Calcium phosphate bone cements (CPCs) are bioceramic materials commonly used in the regeneration of bone defects that require the use of osteogenic and osteointegrative scaffolds. The possibility of functionalizing these materials with therapeutic agents commonly used in the treatment of bone cancer paves the way to the development of new therapies for the treatment of bone cancer and metastasis through the combination between the regenerative skills of CPCs and the anticancer ability of drugs. The present work shows a new approach to modulate drug release from Sr-doped CPCs based on the addition of drug-loaded hydroxyapatite nanoparticles (HANPs) within the cement. HANPs were functionalized with doxorubicin (DOX), a drug commonly used in cancer chemotherapy. Then, the as-obtained doxorubicin-loaded nanoparticles (DOX/HANPs) were mixed in cement formulation achieving a drug release profile that matches the clinical demands. The DOX release profiles from DOX/HANPs, CPC-DOX and CPC-DOX/HANPs were investigated. The data describing the drug release profile were further fitted with mathematical semi-empirical models to elucidate the drug release mechanisms and to design new tuneable release systems. The biological performance of the drug-loaded CPCs was evaluated. This work proves the potential of drug-loaded apatite nanoparticles as functionalizing media able to confer tuneable drug delivery systems to nanostructured apatitic bone cements, which become promising biomaterial for effective local treatment of bone cancer.

3-4

## Synthesis and rheological evaluations of ion-doped calcium phosphate-based bioceramic for bone regeneration

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Calcium phosphate particularly, hydroxyapatite (HA) is widely considered as reference material for bone regeneration, due to its high mimicry with natural bone inorganic matrix. However, fabrication of 3D apatite scaffolds with adequate porosity and mechanical strength for applications in load-bearing sites is still a big challenge. The biological functions of the natural apatite include the ability to exchange bioactive ions with the physiological environment, contributing to modulate the bone cell metabolism. The processing of stoichiometric hydroxyapatite is affected by its chemical composition, since ion doping affects the crystal size and ordering the powder particle size, as well its morphology and surface charge. These properties in turn impact on their rheological properties, relevant when processing ceramic powders into water-based slurries for the production of 3D scaffolds. In the present work, apatitic phases doped with bioactive ions such as $Mg^{2+}$, $Sr^{2+}$, $Mg^{2+}Sr^{+2}$ were synthesized by wet methods and aqueous powder suspensions were prepared to be applied with direct foaming and 3D printing techniques. We compared the rheology of stoichiometric and ion-doped HA suspensions on the basis of different powder and dispersant concentration, to identify the best conditions to achieve stable slurries. The stability of HA suspensions was assessed by pH and ζ-potential measurements, as well as viscosity and viscoelasticity tests. We found that, among the various investigated parameters, doping of apatite with foreign ions strongly impacts the suspension stability, while dispersant showed a clear transition as the powder concentration increased.

3-5

**In vitro cytotoxicity of dental composites: A systematic review**

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The increased demand for both minimally invasive tooth restorations and esthetics has led to an accelerated development of dental composites. Nontheless, enough controversy persists about the safe use and the cytotoxic effects of different groups of dental composites. This systematic review implemented a quality assessment for in vitro studies. Specific searches were conducted and performed in electronic database: Scopus, MEDLINE via PubMed, EMBASE; 21 relevant research articles published between 2012-2022 were selected out of 1300 unique studies. The included considered condition were the studies which evaluated the commercially available dental composites in vitro. 8 different methods of assessing the cytotoxic effect of dental materials were used. 9 in vitro tests were conducted on human gingival fibroblast cells and 7 articles were based on in vitro testing on L929 mouse fibroblast cells. While the lack of methodological standardization among the studies still hinders the establishment of a relationship between types of different dental composites and toxicity; 3 studies imply that dental materials which incorporate ceramic fillers could improve biocompatibility because less monomer is required; whereas 8 studies mention that the toxicity of dental composites could be increased by the unreacted monomers that can be released into the adjacent medium. No ideal dental composite material has been developed until now, so clinicians should be aware of both the performance and limitations of the materials used in order to achieve the desired outcomes and take into consideration all the clinical factors involved.

3-6

**Cartilage regeneration: innovative molecules and systems to improve healing and counteract arthritis**

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Cartilage degeneration is a personal and social problem affecting millions of people worldwide. Considering lack of vascular, lymphatic and nervous system, the spontaneous regeneration of this tissue is complicated and when it happens, the new tissue is clinically suboptimal. It is therefore necessary to use an artificial scaffold to help the regeneration. Hydrogels are really promising, considering their ability to support cells and allow optimal metabolites exchange. Among the hydrogels, Gellan Gum (GG), a polysaccharide produced by the bacteria *Sphingomonas elodea*, is gaining more and more attention thanks to its affordability and its tunable mechanical and biological properties. To demonstrate its suitability as biomaterial for cartilage, three different macrofamilies of Gellan Gum based scaffolds have been developed by using several inorganic and organic nature-derived fillers included to increase mechanical and biological properties and confer the most suitable environment for cartilage regeneration. Biological properties evaluation involved, among the others, the use of a metabolic assay to verify cytocompatibility, the use of the innovative cells/bacteria co-culture system to verify the protective effect of included fillers on cells against pathogenic bacteria often involved in septic arthritis and the use of histological and molecular biology techniques to verify chondrogenesis. Results demonstrated cytocompatibility, protective effect and chondrogenic potential of all the tested materials demonstrating simultaneously Gellan Gum potentiality in tissue engineering.

4-1

## $LaMnO_3$ thin films: Experimental study and a DFT calculation

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Manganate oxides of the perovskite-type have specific properties such as superconductivity, magnetism, piezoelectricity, ferroelectricity and multiferroicity, therefore are widely used in various fields. The perovskite structure of $LaMnO_3$ (LMO) is very sensitive to external stimuli such as electric, magnetic fields and electromagnetic radiation as well as the presence of dopants, which makes this material suitable for applications in high-tech areas such as spintronics and the memory units. The aim of this work was to prepare $LaMnO_3$ thin films by polymer assisted deposition technique and determine the structure and electronic properties of LMO phase by DFT calculations, using the software packages Quantum Espresso and Quantum ATK. In the experimental part of this work, lanthanum and manganate nitrates were dissolved in distilled water and stability of the solution was controlled by addition of EDTA and PEI. The prepared solutions were deposited by spin-coating technique on single crystal substrates and thermally treated at different temperatures up to 900°C. Structure of the obtained films was characterized by XRD, AFM, SEM and TEM.For DFT calculation, the ground state was defined during the geometric optimization by finding the energy minimum in which the structural parameters were determined, and later used in the calculations. The electronic structure calculations were used to obtain band structure, density of states-DOS (total and partial) and electronic density difference-EDD. In addition to the DFT approach which is used for determination of the band structure, the DFT+U approach is also used, including Hubbard potentials as a correction with the assumption of obtaining more accurate results. The evaluation of the obtained results was done by comparison with experimentally obtained data and literature values.

4-2

## Influence of layer thickness and external bias variation on intersubband absorption in n-doped $BaSnO_3$ symmetric quantum wells

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The novel and promising $BaSnO_3$/BaO perovskite-oxide material system has recently attracted a lot of attention due to its many advantages and application potential for optoelectronic devices. Its prominent features include a wide band gap, small electron effective mass, and a very high room-temperature mobility, which makes it attractive for numerous purposes. Here we focus on the calculation of intersubband absorption in La-doped $BaSnO_3$ symmetrical double quantum well (DQW) and triple quantum well (TQW) structures. We analyze the dependence of the fractional absorption on the thickness of the well layers, as well as the effects of an external electric field applied along the growth direction on optical transitions. The latter effect is very important for practical application in e.g. electro-optical light modulators. The electronic structure is calculated self-consistently by solving the Schrödinger-Poisson system of equations where the exchange correlation effects are also taken into account through the modification of the total effective potential.

4-3

**Role of halogen substituents in the design of halogen-containing high-energy materials**

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It is known that halogen interactions can be a tool for modifying the potential above the central regions of the molecular surfaces of halogen-substituted high-energy molecules (HEMs), which is directly related to the sensitivity towards detonation of those molecules. Also, it is known that the substitution of hydrogen with halogen in some organic molecules which contain a nitro group can affect the dissociation energy of the C – N bond. In this work the molecules of 1,4- and 2,3-halo substituted 5,8-dinitronaphthalene were studied. Electrostatic potential maps were calculated for each of these molecules using the PBEPBE/6-311G** level of theory. The WFA-SAS program was used to obtain the maps of electrostatic potential. The dissociation energies of C – N bonds in the mentioned molecules were calculated using the SAPT program. Also, the heats of formation and the Widberg bond order were calculated. The results indicate that the halogens will have a much greater influence on the potentials above the central regions of the molecular surfaces in the case when they are located at positions 2 and 3 in 5,8-dinitronaphthalene. However, halogens in positions 1 and 4 lead to a significant decrease in the dissociation energy of C – N bonds, compared to 2,3-substituted analogues. It is believed that these differences are the results of different characteristics of the halogens, but also their positions in relation to the nitro groups.

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4-4

**Tris-(nitroacetylacetonato) complexes as new high-energy materials**

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Recent advances in high-energy materials studies have shown that coordination compounds are promising energetic compounds with satisfactory detonation properties and moderate sensitivity. Earlier experimental studies found that the nitro-acetylacetonato aluminum (III) complex easily ignites in the air when heated. Theoretical calculations performed on nitroaromatic explosives revealed that molecular electrostatic potential over the C-$NO_2$ bonds is a good tool for determining the impact sensitivity of these molecules. Herein, we calculated the molecular electrostatic potential and bond dissociation energies for several nitro-tris(acetylacetonato) complexes. A rough estimation of the electrostatic potential predicts slightly positive electrostatic potentials above the C-$NO_2$ bonds. These results show that the metal ion replacement may induce the fine adjustment of electrostatic potential above the C-$NO_2$ bonds in the nitro-chelate complexes. The reported results agree with the calculated bond dissociation energies. These values indicate that introducing the transition metals in the nitro-chelate complexes may increase their sensitivity. However, we also synthesized and characterized the nitro-tris(acetylacetonato) cobalt(III) complex. The UV/VIS and FTIR tests confirmed that the synthesized complex was Co(acac-$NO_2$)$_3$. The obtained results agree with the experimental results that Collman et al. reported. The open flame test showed that this complex easily combusts when exposed to the open flame.

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4-5

## Molecular modeling of selected methylimidazolium ionic liquids using GROMACS simulation software

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Molecular dynamics (MD) is one of the tools within computational chemistry, which is used to describe complex chemical systems. This type of molecular modeling enables the understanding of certain macroscopic phenomena by monitoring the microscopic behavior of the observed substance even under extreme conditions. Within this paper three imidazole based ionic liquids (ILs), i.e. [EMIM][$NTf_2$], [BMIM][$BF_4$] and [BMIM][$PF_6$] were simulated with the aim of analyzing further possibilities of their use in dissolving carbon dioxide. The software packages used in this work were GROMACS for creating the simulations, as well as Visual molecular dynamics (VMD) for their analysis and visualization. For each of the simulated systems adequate OPLS-2009IL force filed was used, while each molecule was prepared using Avogadro software. Subsequently, system consisted of 500 molecules of cation and 500 molecules of anion was placed in simulation box. The simulated temperature (298.15 K), pressure (1 bar) and density of the system were achieved using both isothermal-isochoric (NVT) and isothermal-isobaric (NPT) ensembles with the Berendsen method. In addition to the above conditions, the duration of the simulations was also optimized to 40 ns. The simulations were verified by comparison of the densities obtained by simulation, of each of the examined ILs, with their experimentally determined densities. The obtained simulations represent a solid base for further research in the direction of the use of selected ILs in dissolving carbon dioxide. In this way, this work proves the great potential of modern modeling techniques.

4-6

**The effects of alloying elements on mechanical properties of NIOMOL 490K steel**

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This paper is to study the effect of alloying elements on mechanical properties of high-strength low-alloy steel, NIOMOL 490K. This steel grade belongs to the class of molybdenum microalloyed steels, in which microalloying with molybdenum serves to increases the heat resistance of steel along with the effect of increasing the influences of other alloying elements. This steel grade is designed for welded pressure vessels fabrication and is primarily applied for dynamic loading conditions at low operating temperatures. High-strength low-alloy steels used nowadays are usually obtained by means of suitable chemical composition and thermo-mechanical treatment. In present paper, the tensile and hardness tests were used to determine the effect of mechanical properties of NIOMOL 490K steel.

4-7

**Characterization of fracture behavior of a low carbon microalloyed steel for elevated temperature application**

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The idea of this research was to collect data on the effect of operating temperature on the impact toughness properties of low-carbon microalloyed steel intended for elevated temperatures application. The aim of this investigation was to determine the effects of temperature as well as the effects of specimen orientation with regards to the rolling direction, on the impact toughness and the relation between its components. Charpy specimens were made from virgin material and were tested at room and operating temperature of 540 ℃. Specimens were cut from the pipe in two directions, along the rollind direction (L-) and transverse to the rolling direction (T-). The tests were performed on an instrumented Sharpy pendulum 150/300 J, results show the total impact energy values, Etot, crack initiation energy, Ei, and crack propagation energy, Ep. The macroscopic and microscopic specimens' fracture surfaces are shown. Obtained results of impact tests energy values, correspond to the SEM micrographs of fractured surfaces.

4-8

**Calibration of discrete element method parameters to simulate a planetary ball mill**

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Planetary ball mill is a powerful tool, which has been used for milling various materials for size reduction. The discrete element method (DEM) was used to simulate the dynamics of particle processes in a planetary ball mill. This work includes the calibration of DEM parameters to simulate a planetary ball mill using EDEM Altair 2021.2 software, which provides both faster workflows and results. The input parameters changed to a close correlation between the simulation and experimental results are attained. The results showed that the standard tests could be used to generate various experimental reference values for the calibration. The numerical modeling results agree with the experimental, indicating that the calibrated parameters are accurate.

5-1

## High-temperature tribological testing of magnetron sputtered nanolayered TiAlN/TiSiN coating deposited on tool steel

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In this work, nanolayer TiAlN/TiSiN coating was deposited on hot-working tool steel (EN X38CrMoV5) and plasma nitrided (PN) hot-working tool steel, using industrial magnetron sputtering unit. High temperature tribological behavior of the coating was evaluated against $Al_2O_3$ counterbody using pin-on-disk tribometer. The tests were conducted in air atmosphere at room temperature (RT), 300, 400, 500, 600 and 700 °C. After the tests, tribo-tracks were examined by confocal microscopy (CFM), stylus profilometry, scanning electron microscopy (SEM), focused ion beam (FIB) and energy dispersive spectroscopy (EDS). Mechanical properties and adhesion of the coating, before and after tribo-tests, were evaluated by nanoindentation and HRC tests. The investigated coating retained its mechanical properties and adhesion at high temperatures, for both substrate materials. Tribological tests at RT produced wear tracks that displayed abrasive wear mechanism, while both abrasive and oxidative mechanisms are observed at high temperatures. At RT, steady state coefficient of friction (COF) was ~0.8 for coating on both substrates. At 300, 400 and 500 °C increase of COF is observed due to Al-O/Ti-O layer that forms inside of the wear tracks. At 600 and 700 °C COF decreased to lower values (~0.6). Decrease of COF is suggested to be due to degradation of coating and formation of Fe-O inside of wear track. The highest wear rate was determined for the coating tested at RT. At high temperatures the measured wear rate was up to 10-fold lower than at RT. However, wear rate increased with increase in testing temperature. Complete coating degradation inside of the wear track occurred due to substrate oxidation at 700 °C, for coating deposited on tool steel. On the other hand, coating at the same location on PN tool steel was only partially destroyed at the same temperature. It is concluded that plasma nitrided layer shifted coating's degradation to higher temperatures. Therefore, in order to successfully evaluate high temperature tribological behavior of coatings it is necessary to use substrate materials that can withstand the testing temperatures.

5-2

**The role of copper doping on physicochemical properties of bismuth vanadate**

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Production of gasses such as hydrogen and oxygen on a large scale is of the great importance both in industry and in environmental protection. To achieve it, photoelectrochemical (PEC) water splitting has been regarded as promising method and the developement of new semiconductors holds a key role to the efficent application. Due to its great light harvesting ability, band edge positions and low-cost synthesis method, bismuth vanadate ($BiVO_4$; BVO) has been intensively studied as a photoanode material for water splitting. To overcome limitations such as charge carriers recombination, material should be doped with different transition metal elements. In this work physicochemical properties of pristine and 1%-, 2.5%- and 5%- Cu-doped BVO powders, solvothermaly synthesized at 180°C for 20 h, were reported. X-ray diffraction (XRD) study indicates that, depending on the doping level, the material exists in monoclinic or tetragonal scheelite phase, but mixed phase composition was also observed. Pure monoclinic and tetragonal phase was formed in a case of pristine and 1% doped sample, respectively, while 2.5%- and 5%- Cu-doped BVO exhibit presence of both phases. Scanning electron microscopy (SEM) reveals that sample with monoclinic phase consists of irregular worm-like morphology, while morphology of tetragonal samples was mostly spherical. For 2.5%- and 5%- Cu-doped samples a combination of prismatic and spherical shape morphology was observed. Local structure of material was examined with Raman spectroscopy and the results were in accordance with XRD study where band positions well matched the phase composition. Optical properties were characterized with UV-Vis Diffuse Reflectance Spectroscopy (DRS) and Photoluminescence (PL) spectroscopy. The band gap of monoclinic samples was in range 2.4-2.5 eV, while band gap of sample with tetragonal phase has band gap was between 2.8 and 3 eV. Dual phase samples had two different band gaps that originate from presence of both phases. Based on the results obtained from the PL spectra, monoclinic samples possess better recombination features than tetragonal ones. Photoelectrochemical measurements of BVO samples imply that doping of material improves performance towards oxygen evolution reaction.

5-3

**Mechanochemically modified composites of molybdenum disulfide and graphene oxide for hydrogen evolution reaction**

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Molybdenum disulfide has shown significant catalytic activity for hydrogen evolution reaction (HER) due to its layered structure with large number of active sites. However, the activity is limited by poor electron transport perpendicularly to the $MoS_2$ sheets. To overcome this problem, conductive materials are often being added to $MoS_2$ to enhance electron transfer between the active sites and the electrode. Graphene oxide has high specific surface area, adjustable surface chemistry and electronic properties which makes it suitable for the synthesis of composites with $MoS_2$ in order to improve HER activity of the material. $MoS_2$ has been synthesized hydrothermally, while GO was obtained by modified Hummers' method. Composites were prepared with different mass ratio of the components. In this work, the composites were obtained by sonication of aqueous suspension of $MoS_2$ and GO, followed by overnight drying in the air at 70°C and mechanochemical modification using SPEX Mixer/Mill 5100. The surface and structural properties of composites after milling are investigated and their activity toward hydrogen evolution reaction is compared.

5-4

**Investigation of dissolution and redeposition mechanisms of high surface area carbon supported Pt alloys for oxygen reduction reaction in low temperature proton exchange membrane fuel cells**

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Low-temperature proton exchange membrane fuel cells (LT-PEMFC) showed great potential in efficiently converting chemical energy stored in hydrogen to electrical energy. The sluggishness of the catodic oxygen reduction reaction (ORR) needs further improvement in order for LT-PEMFC to reach commercial use. Alloying platinum nanoparticles with the less noble metal allows for the decrease of the Pt content as well as the improvement in the electrocatalytic activity of the material. The main issue with Pt alloyed nanoparticles is their instability. Here presented is the novel methodology based on the "spot the difference" principle where identical location investigation of the same nanoparticle.1 It consists of combining modified floating electrode (MFE) designed to test electrochemical properties of electrocatalysts at high current densities and scanning transmission electron microscopy (STEM). This methodology enables the analysis of atomic resolution micrographs of the identical location, i.e. the same nanoparticle. Home made image registration and atomic positioning algorithms were made in order to analyse the dissolution and redeposition mechanisms of the commercial carbon supported Pt-Co alloy.

5-5

**Electrochemically-grown chloride-free $Cu_2O$ nanocubes favorably electroreduce $CO_2$ to methane: The interplay of appropriate electrochemical protocol**

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Nowadays, electrochemical $CO_2$ reduction reaction ($CO_2RR$) to value-added products represents one of the major challenges in electrocatalysis. Copper-based nanocubes (Cu NCs) have been proposed as the front-runner's catalyst for the production of $C_{2+}$ products at the industrial level. However, their selectivity ($C_1$ vs. $C_2$ product distribution) is rather complex depending on the dynamic structural transformations, the presence of mixed $Cu^+/Cu^0$ states, the microenvironment, and nanocatalyst-support interactions. Commonly, electrochemically-grown Cu NCs are prepared in the presence of chlorides that acts as a shaping agent. In this study, an optimized electrodeposition method for the synthesis of $Cl^-$-free $Cu_2O$ nanocubes on a glassy carbon substrate with uniform size, shape, and loading is established. The successful preparation of chloride-free cuprous oxide nanocubes ($Cu_2O$ NCs) was confirmed with X-ray diffraction (XRD), Raman spectroscopy, scanning electron microscopy (SEM), and X-ray photoelectron spectroscopy (XPS) analyses. We report how the electrochemical double-layer capacitance (EDLC) method for electrochemical surface area (ECSA) determination with(out) subsequent return to the open-circuit potential (OCP) conditions before electrolysis influences the $CO_2RR$ activity/selectivity. When $Cu_2O$ NCs are subjected to the EDLC method (often considered a non-invasive method) and exposed to the OCP before electrolysis, they become active for methane formation. Moreover, the influence of the potential window width (i.e. 200 and 400 mV) in which the EDLC-ECSA is employed and its correlations with the selectivity is presented. We underline the importance of the ECSA determination method and OCP on/off state as a triggering factor for reactivity/selectivity of particular $Cu_2O$ NCs for $CO_2RR$ and further emphasize the reconstructive nature of $Cu_2O$ NCs under $CO_2RR$ relevant conditions.

5-6

**Lithium-ion insertion into anatase $TiO_2$ nanotube arrays at room temperature**

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High demand for efficient storage devices has set a goal of improving the efficiency of lithium-ion batteries (LIBs), which currently represent the most promising energy storage devices . Most of the commercial LIBs today are composed of graphitic-based anodes, which are not suitable for high performance applications, such as electric vehicles. In this context, there is an increased interest in the development of novel anode materials, with enhanced kinetics. Such an electrode with enhanced capabilities could be $TiO_2$ nanotube arrays (NTAs). In this paper, anatase $TiO_2$ NTAs were prepared by anodization of a Ti foil in the solution of $NH_4F$ in glycerol at the voltage of 45 V and subsequent annealing at 400$^oC$. The presence of anatase $TiO_2$ was confirmed by Raman spectroscopy and the morphology was observed by scanning electron microscopy (SEM), while the electrochemical insertion of Li-ion in nanotubes was studied by means of cyclic voltammetry (CV) and galvanostatic (GS) charge-discharge experiments by exposing the electrode to the 1M solution of $LiClO_4$ in propylene carbonate. The CV response was fast at all scan rates, up to 50 $mV \cdot s^{-1}$, with characteristic $Ti^{4+}/Ti^{3+}$ redox peaks. The $Ti/TiO_2$ NTAs electrode was GC cycled at different current densities (in orders 100, 50, 25 and again 100 $\mu A \cdot cm^{-2}$) at room temperature. After the initial 50 cycles the insertion/extraction capacity amounted 191.1/170.1 $mAh \cdot g^{-1}$. By decreasing the current density, capacity significantly rises to 268.4/243.3 and 347.8/312.3 $mAh \cdot g^{-1}$ at 50 and 25 $\mu A \cdot cm^{-2}$, respectively. After the last cycle at 100 $\mu A \cdot cm^{-2}$, capacity amounts 188.9/168.1 $mAh \cdot g^{-1}$, which is about 99% of the initial capacity. The diffusion coefficient of Li-ion was calculated to be $7.06 \cdot 10^{-16}$ $cm^2 \cdot s^{-1}$ during deintercalation and $8.16 \cdot 10^{-16}$ $cm^2 \cdot s^{-1}$ during intercalation.

5-7

**Tuning the stability of graphene derived carbon support in polymer electrolyte membrane fuel cell electrocatalysts**

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Proton exchange membrane fuel cells (PEMFCs) have attracted wide attention due to their high energy efficiency and zero harmful emissions. However, providing high catalytic activity and long-term durability of the electrocatalyst remains a challenge. Currently, the most common oxygen reduction reaction (ORR) electrocatalysts are based on platinum or platinum alloy nanoparticles supported on commercially available high surface area carbons. Despite many good inherent properties of such carbons, the major downside remains poor electrochemical stability that results in carbon corrosion which leads to lower catalyst performance over time. In recent years, alternative carbon support materials such as graphene derivatives have emerged as a potential solution towards the improvement of catalyst composite durability with a potential to reach the US Department of Energy year 2050 targets of 8000 and 30 000 hours of system lifetime for light duty vehicles and heavy duty vehicles, respectively. However, utilization of these materials as an adequate substitution with today's state-of-the-art carbon black supports proved to be a very challenging task, especially at high scale production. Different chemical and physical properties ascribed to graphene derivatives apart from carbon blacks could provide for improvement in durability of the catalyst composite. Here we show that when graphene derivatives get appropriately exploited for the use as supports for ORR catalysts, these benefits provide significant improvements in terms of long-term durability resulting from increased resistance against carbon corrosion. This is of crucial importance to meet the ambitious targets of US Department of Energy.

6-1

**Galvanostatic charge/discharge of thermally treated and ion-beam irradiated graphene oxide/12-tungstophosphoric acid nanocomposites**

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Applicability of graphene oxide (GO) in supercapacitors is highly dependent on its surface chemistry, porosity and structure. These properties of GO can be modified by thermal treatment or by ion beam irradiation. Additionally, 2D nature and different active sites make this material desirable for synthesis of nanocomposites with large variety of compounds. In this work composites of GO and 12-tungstophosphoric acid (WPA) with 6 and 13 wt.% of WPA were synthesized. The obtained composite was modified with thermal treatment up to 400 °C in argon atmosphere and ion beam irradiation (hydrogen and nitrogen ions, 15-75 keV and swift heavy xenon ions, 150 MeV). Galvanostatic charge-discharge was used for assessment of charge storage properties while Raman spectroscopy, XPS, XRD and SEM methods were used for investigation of structure, surface chemistry and morphology. Capacitance of pristine and low energy irradiated samples was substantially low which was connected to low conductivity of these samples and low penetration depth of the used ions. Swift heavy ion irradiated GO showed improved capacitance which was associated with desorption of oxygen groups, as observed by XPS and XRD methods. Gradual structural modification of GO with increasing fluence of irradiation was confirmed with Raman spectroscopy while formation of holes was observed in SEM micrographs. The irradiated nanocomposites showed improved capacitance and cycling stability compared to GO. Thermal treatment was also proven beneficial for electrochemical properties of GO and nanocomposites.

6-2

**Determination of electrochemically active surface area of Ir-based catalysts for oxygen evolution reaction**

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In the future energy scenario, hydrogen is seen as a promising alternative to currently used fossil fuels. Proton exchange membrane (PEM) electrolysis is recognized as the best technology for the sustainable production of hydrogen, however, its widespread utilization is jeopardized by the fact that the catalyst, used for the anodic oxygen evolution reaction, is based on scarce iridium. One of the strategies to reduce its loading in the electrolyzer is the dispersion of Ir-based nanoparticles on ceramic supports, which can withstand harsh conditions in the electrolyzer. The newly designed materials for electrocatalytic applications, pursuing this goal, are generally first tested on the laboratory scale. The most important parameters, revealing insights into their viability are their activity, stability, and selectivity. The best metric, revealing the activity of the catalyst is the so-called turnover frequency (TOF), which is in reality difficult to obtain. Instead, normalization of the current by the electrochemically active surface area (ECSA) is used. Unfortunately, there are currently no methodologies for its determination in the case of supported Ir-based catalysts. A promising methodology was recently proposed by Watzele et al., which suggested the use of electrochemical impedance spectroscopy (EIS) to measure the so-called adsorption capacitance of reaction intermediates, which is directly related to the number of active sites. In their work, the authors showcased this methodology on thin films. In our contribution, we propose an upgrade of the methodology to enable its use also on powdered nanomaterials with the inclusion of several parameters besides adsorption capacitance and suggest some directions for the future improvement of this promising methodology.

6-3

**Atomically resolved structural changes of TiON-supported Ir oxygen evolution reaction catalyst**

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Hydrogen technologies are one of the proposed solutions for clean and sustainable energy conversion and storage. However, the cost-effectiveness of the electrocatalysts for proton exchange membrane water electrolyzers, commonly containing scarce and expensive metals, remains a challenge. Synthesizing metallic nanoparticles and dispersing them over a high surface area support helps solve this problem, but requires advanced characterization techniques to explain their complicated structure-property relationships. This work focuses on investigating the structure-stability relationship of a TiON-supported Ir electrocatalyst for the oxygen evolution reaction *via* tracking the Ir nanoparticles' structural changes at the atomic level. An Ir/TiON sample was synthesized on a TEM grid, which was used as a working electrode in a modified floating electrode apparatus. Identical-location scanning transmission electron microscopy was used to record the sample structure at different points of the electrochemical protocol. Subsequently, in-house image analysis algorithms were used to reveal and quantify surface roughening as the predominant degradation mechanism. These results help understand the complicated processes in electrocatalysts with ceramic-supported metallic nanoparticles for usage in water electrolyzers.

6-4

**The biocorrosion activity of ZnO-based materials as biosensors**

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Due to their biocompatibility, chemical stability, high isoelectric point, electrochemical activity, high electron mobility and ease of synthesis by diverse methods, ZnO-based materials have attracted much interest as materials for biosensors. Its unique properties allow it to be used for single-molecule detection and determining various biomolecules, so it can be potentially utilized as biosensor for medical diagnosis. The materials being used as biosensors require special characteristics including high corrosion resistance. The aim of this research was to investigate biocorrosion properties of ZnO materials in Ringer's physiological solution as a function of immersion time. ZnO powders were prepared by microwave (MW) processing of a precipitate in the presence of a different amount (5, 10 and 20 wt.%) of two different surfactants, CA and CTAB. The particles crystallinity and phase purity were investigated by X-ray powder diffraction (XRD) and Raman spectroscopy. Fourier-transform infrared (FTIR) spectroscopy was used to analyze surface chemistry. The particles morphology and textural properties were observed with field emission scanning electron microscopy (FE-SEM) and BET. The biocorrosion activity of the materials was measured by potentiodynamic polarization technique. Prepared samples were immersed in Ringer solution for different immersion times ranging from 30 min to 7 days. We found that all examined ZnO samples have low biocorrosion activity. Slight differences in biocorrosion activity between the samples are determined by particles morphology, textural properties and surface chemistry influenced by used surfactants.

6-5

## Taming the morphology of ZnO nanomaterials with chemistry

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The conducted research compares three different chemical routes for the synthesis of ZnO nanoparticles. Simple sol-gel method was used to synthesize fine nanoparticles with a minimum of laboratory requirements. Ionic liquid assisted method was utilized aiming to study the influence of a specific solvent, the 1-butyl-1-methylpyrrolidinium bis(trifluoromethanesulfonyl)imide on the morphology of the synthesized nanomaterial. A conventional hydrothermal method was also investigated due to the expected unique flower-like morphology. Before calcination, physico-chemical features of the prepared precursors were studied using the thermo gravimetry and differential scanning calorimetry (TG-DSC). The structural properties of the synthesized materials were characterized by X-ray diffraction spectroscopy and scanning electron microscopy (SEM). Measured XRD spectra revealed that all samples have a wurtzite crystal structure and that no other phases or impurities were present. The sample synthesized with the sol-gel method had the most broader diffraction peaks, indicating the lowest particle size, followed by the sample with sol-gel ionic liquid assisted synthesis, and the sample obtained with the hydrothermal method. SEM micrographs of investigated ZnO samples showed interesting variations in nanostructures and material morphologies, ranging from spherical particles with a highly uniform size to the network of uniform and homogenous flower-like structures and self-assembled nanosheets. Analysis of optical absorption revealed that all synthesized samples have dominant absorption peak at about 370 nm, which is the characteristic band gap absorption of ZnO electronic structure. A comparison of the synthesis methods leads to the conclusion that the sol-gel process yielded lower nucleation and crystallization temperatures. The ionic liquid-assisted method provided an interesting pathway toward the synthesis of ZnO nanomaterials with properties suitable for application in optical technologies. The hydrothermal method revealed that synthesized ZnO material has unique flower-like morphology that is desirable for application in technologies where high active surfaces play a crucial role.

6-6

## Mechanical properties of jute/nano-$ZrO_2$ composite laminates

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The study of mechanical performances of natural fiber–based composites has gained considerable momentum since they are being seen as a potential eco-friendly alternative to popular synthetic fiber–reinforced composites. Due to that, in this study, the hybrid jute/nano-$ZrO_2$ composite laminates based on the styrene-free polyester resin (UPe) reinforced with 5,0 wt.% of nano-$ZrO_2$ and woven jute fabric was fabricated using combined hand layup and vacuum technique. In order to optimize the nano-$ZrO_2$ reinforcement content in UPe matrix, the viscosity curves for nano-$ZrO_2$/UPe mixtures with 1.0, 3.0 and 5.0 wt% nano-$ZrO_2$ were determined and the 5.0 wt% content of nano-$ZrO_2$ was selected as most promising in the development of jute-based laminate. The jute fabric/matrix weight fraction ratio was 1:1. FT-IR spectroscopic analysis was used to investigate the structural properties of raw materials and laminate as well. Uniaxial tensile tests confirmed significant mechanical stability of the designed laminate with achieved tensile strength of 60.5 MPa and maximal force of 2.1 KN. The influence of the content of the jute fabric and nano-$ZrO_2$ reinforcement on glass transition temperature ($T_g$) was determined using dynamic-mechanical analysis, and a significant increase of $T_g$ was observed in composites.

6-7

## Effect of disorder and electron-phonon interaction on 2*H*-$TaSe_{2-x}S_x$ lattice dynamics probed by Raman spectroscopy

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Transitional metal dichalcogenides have attracted a lot of attention due to their rich phase diagrams, thickness-dependent transport, distinctive optical characteristics, and the emergence of collective electron phenomena (e. g. charge density waves - CDW and superconductivity) which can co-exist, contrary to what was predicted by previous theoretical studies. Given that both superconductivity and CDW phase have been experimentally confirmed in the crystal alloys of 2*H*-$TaSe_{2-x}S_x$, these materials represent perfect candidates to investigate an intricate connection between these two phenomena. Additionally, it was recently shown that in the metallic single crystal alloys of 2*H*-$TaSe_{2-x}S_x$ the crystalline disorder favours superconductivity while suppressing CDW phase. In this study, Raman spectroscopy was used to investigate the lattice dynamics of 2*H*-$TaSe_{2-x}S_x$ ($0 \leq x \leq 2$) alloys. Experimental results were compared to density functional theory (DFT) and density functional perturbation theory (DFPT) calculations. In the Raman spectra of pristine samples two out of three symmetry predicted Raman active modes were observed, with the missing mode being unobservable in the used backscattering geometry. Experimental values of phonon energies are in good agreement with theoretical calculations. The temperature dependence of phonon energies and line widths directly reflects existing CDW transitions. The Raman spectra of doped materials were compared to those of pure samples in order to inspect how the electron-phonon interaction and crystallographic disorder affect the phonons. Additional peaks and a dramatic development of the two-phonon structure are detected in the Raman spectra of the doped samples. A signature of the crystallographic disorder can also be identified in the sulfur content dependence of phonon energies, line widths and Fano parameter.

7-1

## Crystal structure of $InSiTe_3$ studied by Raman spectroscopy

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Even though the first report of $InSiTe_3$ single crystal synthesis and its structure dates from about 30 years ago, unlike its related compounds ($CrSiTe_3$, $CrGeTe_3$), there has been only a few studies availabile. One of the reasons behind the lack of research data is the fact that its crystal structure is not unambigously determined. Raman scattering study of of $InSiTe_3$ reveals presence of six ($3A_{1g} + 3E_g$) out of eight and seven ($5A_g + 2E_g$) out of ten Raman active modes for proposed $P\bar{3}1m$ and $P\bar{3}$ space groups, respectively. These results suggest the coexsistence of two triagonal crystal phases, high symmetry one, $P\bar{3}1m$ and a lower symmetry one, which corresponds to $P\bar{3}$ space group. The theoretical predictions obtained by DFT calculations for both space group support this scenario. In addition to the symmetry predicted modes, at around 500 $cm^{-1}$ a mode ascribed to the $A_{1g}/A_g$ mode „splitting“ is detected. The emergence of additional peak could be a consequence of local symmetry breaking due to a small difference in lattice parameters of both crystal phases. The temperature dependence of energies and linewidths of most prominent Raman active modes is also presented in the temperature range from 80 to 300 K. Monotonous decrease in energy and increase in linewidth is present upon heating up to 200 K. Around this temperature discontinuities in properties of all analyzed modes are detected. Yet, due to lack of theoretical and experimental studies of this material this anomaly still remains an open question.

7-2

**Optical properties of nanostructured multi-stoichiometric tungsten suboxides**

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Tungsten suboxide ($WO_{3-x}$) nanomaterials were synthesized via chemical vapor transport method and the role of their crystal structures on the optical properties was investigated. These materials grow either in the shape of platelets or nanotiles, or as nanowires ($W_5O_{14}$, $W_{18}O_{49}$). For the first one which represents thin quasi-2D materials, the appearance of defect states gives rise to two indirect absorption edges. One is assigned to the regular bandgap between the valence and the conduction band, while the second is a defect-induced band. While the bandgap values of platelets and nanotiles are in the upper range of the reported values for the suboxides, the nanowires' bandgaps are lower due to the higher number of free charge carriers. Both types of nanowires sustain localized surface plasmon resonances, as evidenced from the extinction measurements, whereas the quasi-2D materials exhibit excitonic transitions. Photoluminescence emission peaks in the UV region were detected for all four materials. The interplay of the crystal structure, oxygen vacancies and shape can result in changes in optical behavior, and the understanding of these effects could enable intentional tuning of selected properties.

7-3

**Development of self-assembling bioactive hydroxyapatite nanorods**

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Hydroxyapatite (HA) is a calcium phosphate widely used in bone tissue engineering thanks to its biocompatibility and strong mimicry with the main inorganic component of human hard tissues (e.g. bone and teeth), in turn eliciting excellent osteogenic character that enables the development of biomaterials suitable for regenerative medicine, without using any growth factors. Relevant aspects determining the apatite bioactivity are related to multiple ion substitutions in the lattice structure and to specific crystal organization both affecting cell chemotaxis and bio-resorption behaviour. In the present work apatite nanocrystals were synthesized by different routes to investigate the effect of different ions doping such as $Mg^{2+}$, $CO_3^{2-}$ and $Sr^{2+}$ as well as the effect of specific crystal orientation, on the fate and metabolism of stem cells towards specific phenotypic differentiation. To this purpose, wet synthesis routes carried out at body temperature or under hydrothermal conditions were applied for the synthesis of apatite nanoparticles, particularly using organic molecules as templates driving the nucleation pathway and specific crystal orientation of the apatitic phase. With this latter process we could obtain self-assembled hydroxyapatite nanorods, of which we investigated the chemico-physical and their ability to functionalize drugs on its surface, for drug delivery purposes. The enhanced ability to trigger signalling mechanisms instructing cells to activate and sustain the natural physiologic metabolism is a key element to the design of novel biomaterials capable to regenerate biological tissues such as bone.

7-4

## Chitosan-stabilized magnetic nanoparticles for application in medicine

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Magnetic nanoparticles (MNPs), due to their specific magnetic properties and low toxicity, can help solve problems in several fields of medicine, especially in magnetic resonance imaging (MRI) as contrast agents, magnetic hyperthermia, and in the treatment of diseases associated with protein aggregation. However, one of the critical factors of MNPs application is their stability in biological media. A natural or synthesized polymer can modify MNPs to ensure their stability. This presented work is focused on preparing MNPs by the coprecipitation method followed by their coating with chitosan (a bioactive polymer) to obtain stable chitosan-modified MNPs (Chit-MNPs). Moreover, a comprehensive physicochemical characterization of uncoated MNPs and Chit-MNPs was carried out to determine their structure, morphology, MRI parameters ($T_1$ and $T_2$ relaxation times), and magnetic and bioactive properties. The data from TEM images showed that the Chit-MNPs samples contained roughly spherical shapes of MNPs with a diameter of 10.7 ± 0.1 nm. Increase of ζ-potential value of MNPs (+18 mV) to value +48 mV for Chit-MNPs confirms successful chitosan adsorption on MNPs surface. From MRI analysis the relaxation rate (R) and relaxivity (r) have been calculated: $r_1$ = 0.713 $mM^{-1}s^{-1}$, $r_2$ = 238.16 $mM^{-1}s^{-1}$, and $r_{2^*}$ = 276.1 $mM^{-1}s^{-1}$. The high $r_2/r_1$ ratio (334) indicates that the prepared samples has a significantly prevailing effect on the transversal relaxation time ($T_2$) compared to longitudinal relaxation time ($T_1$). Next, the specific absorption rate (SAR) values of Chit-MNPs were calculated, and their increase with the applied magnetic fields *H* up to ~7.9 $kA \cdot m^{-1}$ was observed. Finally, the ability of Chit-MNPs to destroy α-lactalbumin amyloid fibrils (αLAF) was studied using ThT assay and AFM microscopy. These results demonstrate that our Chit-MNPs can be used as a contrast agent for MRI, nanoheaters for hyperthermic treatment and nanoparticles with amyloid-destroying properties.

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7-5

## Nanostructured $TiO_2$@$SiO_2$@$FeO_x$: Application in photocatalysis

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Colored organic compounds which can be found in wastewaters represent a serious threat to the environment hence it is of great importance to remove them efficiently. One of frequently used methods for the degradation of organic dyes is the photocatalysis. As an economically and ecologically acceptable and photocatalytically active material, titanium dioxide in the anatase form is usually used as an efficient photocatalyst. However, the removal of this material from the reaction mixture after the photocatalysis process prevents its wide application. Nowadays, centrifugation and filtration are in use, but these methods are complicated and unprofitable. In order to simplify the removal process, a photocatalyst with magnetic properties and core-shell structure has been synthesized in this research. Magnetic core was synthesized by the co-precipitation method and subsequently coated with layers of $SiO_2$ and $TiO_2$ by sol-gel method. The material was dried at 80°C after synthesis of each layer, which was followed by the final calcination at 500°C. The synthesized composite was characterized using XRD, SEM and EDS. Photocatalytic activity of the synthesized catalyst was tested on azo dye Reactive Orange 16 solution under the simulated sunlight. Based on XRD analysis, it was concluded that the synthesized composite consisted of $TiO_2$ in the anatase form, amorphous $SiO_2$, $Fe_3O_4$ and $Fe_2O_3$. The presence of amorphous $SiO_2$ was confirmed by a slight increase in background of the XRD pattern at low 2θ values. Based on SEM micrographs, it was concluded that the composite particles have uniform size and shape. Their ellipsoidal magnetic core, consisting of $Fe_3O_4$ and $Fe_2O_3$ with dimensions 350×450 nm, is coated with a uniform 50 nm thick layer of $SiO_2$ and $TiO_2$. The synthesized composite showed photocatalytic activity by degrading 66.1% of the Reactive Orange 16 dye after 90 minutes of irradiation. Although $TiO_2$@$SiO_2$@$FeO_x$ shows slightly lower efficiency in comparison with pure $TiO_2$, it possesses a significant advantage: it can be easily removed from the reaction mixture using magnet. The investigation of $TiO_2$@$SiO_2$@$FeO_x$ efficiency toward other polluting dyes is planned, together with the optimization of photocatalysis parameters.

7-6

**Thermo-physical properties of epoxy resin reinforced by single-walled and multi-walled carbon nanotubes**

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Polymer nanocomposites are known as materials that exhibit outstanding thermo-physical properties, however commercial mass production of polymer composites reinforced by carbon nanotubes is very much dependent on the standards of technological process. As such, it requires experimental methods to control the influence manufacturing conditions, of which one of the most important is the nanofiller dispersion uniformity. In this research we focus on experimental investigations of the thermal conductivity of engineered polymer nanocomposites, prepared by integration of different amounts of single-walled and multiwalled carbon nanotubes (CNT) in the epoxy matrix structure. Dispersant addition of a relatively small quantity of CNTs is known to cause significant modifications in properties of initial epoxy host and in this particular study the emphasis is made on revealing how increased loading level and/or dispersion quality affects overall thermosetting features of the composite material. Nanocomposites comprising commercially available epoxy resin and carbon nanotubes with an average outer diameter of about 2 nm and lengths in range between 5 and 30 microns were prepared in the form of cylindrical sample of 17 mm height and 7 mm in diameter. Visual thermographic analysis and direct thermal response measurements are employed to collect relevant data and shed light on the peculiarities of nanofiller incorporation into the host polymer matrix. Experimental setup is built upon NI USB-6009 DAQ unit controlling 5V/1A electrical furnace with flat heated surface on which cylindrical samples were placed. Temperature of the opposite edge of the samples was measured by thermocouple. Signal from thermocouple was acquired through one of the analog channels of the DAQ module with 14-Bit resolution and 48 kS/s sample rate, sufficient to collect reliable temperature vs time plots in heating and cooling modes. Experiment was set up to be fully managed by custom-developed NI LabVIEW software. Visual insights about heat flow processes in the samples were gained with the help of FLIR TG series thermal camera. Mechanisms behind the effects causing differences in thermo-physical behavior of single-walled and multi-walled carbon nanotubes reinforced epoxy composites are discussed based on the recorded thermal response.

7-7

## Free-volume transformation in the $BaGa_2O_4$ ceramics caused by $Eu^{3+}$ Ions

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The aim of this work is description of thermally-induced degradation processes. The $BaGa_2O_4$ ceramics are considered as promising material for use as insulator in optoelectronic devices, as a secondary coating for plasma panels, etc. The doping of impurities in the form of rare-earth ions leads to the expansion of the functional properties of such ceramics. The goal of this work is to study the evolution of inner free volumes (extended defects and nanopores) in $BaGa_2O_4$ ceramics doped with different amounts of $Eu^{3+}$ ions using positron annihilation lifetime spectroscopy (PAL) method. The evolution of free-volume defects in the $BaGa_2O_4$ ceramics obtained by solid-phase synthesis from the initial $BaCO_3$ and $Ga_2O_3$ components with the addition of different amount of $Eu_2O_3$ content (1, 3 and 4 mol%) were investigated. The ORTEC system with $^{22}Na$ isotope as positron source were used for PAL measurements. Investigation was performed at 22 $^oC$ and relative humidity of 35 % for two identical ceramic samples placed in a sandwich configuration. The measured PAL spectra were calculated using LT software at four-component fitting procedure as for spinel ceramics with branched porous structure. For the $BaGa_2O_4$ ceramics two PAL channels are possible: capture of positrons by bulk defects with short and medium positron lifetimes, as well as channel of decay of ortho-positronium atoms with a long lifetime. The short-term component reflects the microstructural features of the main phase, the middle one is connected with defect-related voids near grain boundaries and the lifetimes of the third and fourth long-term components are estimated the transformation of nanopores. Additional phases in ceramics are mainly localized near the grain boundaries and create defective centers for positron capture studied by PAL spectroscopy. Analyzing the second component of PAL spectra for the undoped and $Eu^{3+}$-doped $BaGa_2O_4$ ceramics, it was shown that an increase of $Eu^{3+}$ content from 1 to 3 mol% leads to agglomeration of free-volume defects near grain boundaries of ceramics. At the same time, nanopores in ceramics expand and their number increases. Further increase in the content of $Eu^{3+}$ ions are accompanied with fragmentation of both free-volume defects and nanopores.

8-1

## Thin film polyaniline/silver nanowires nanocomposites for optoelectronic applications

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As one of the essential building blocks of optoelectronic devices, transparent electrodes (TE) act as layers for transfering and collecting charge, transmitting light and providing a distributed electrical field. Indium tin oxide (ITO) is one of the most applied TE due to its high optical transmittance and low electrical sheet resistance. Although these intrinsic optoelectronic properties are favorable, ITO has numeruous drawbacks such as low flexibility, high price, low transmitting of the UV part of the spectrum and high processing temperatures, which is why the need for exploring alternatives is ever-rising. Among numerous TE solutions, silver nanowires (AgNW) are very promising candidates due to their high optical transmittance, low electrical sheet resistance and ease and hence cost of processing. Naturally, as with all materials, AgNW exhibit drawbacks, including high surface roughness, poor substrate adhesion and low chemical stability which hinders their range of TE applications. To overcome these drawbacks, AgNWs can be utilized within a polymer nanocomposite, maintaining the desirable properties of AgNW while simultaneously creating new charge pathways, increasing adhesion, lowering surface roughness and improving chemical stability. In this work polyaniline (PANI)/AgNW nanocomposites have been processed using spin coating, where PANI was coated, at various wt%, onto AgNWs which have been thermally welded in order to decrease sheet resistance. Following the deposition of the polymer, the nanocomposite was doped in ortho-phosphoric acid as to transform the PANI from it's non-conductive state, emeraldine base (EB) to its conductive state – emeraldine salt (ES). The optimal ratio of optoelectronic properties, such as transmittance and sheet resistance was achieved with the composition of 1:1 solution of AgNW/IPA and 1 wt% PANI. The achieved values of 84.02% and 12.08 Ω/□ for transmittance and sheet resistance, respectively, give insight to the TE application potential of this material.

8-2

**Solar cells for window applications**

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Organic solar cells have the potential to provide low-cost photovoltaic devices as a clean and renewable energy resource, offering flexibility and easy processing. In addition, by choosing different materials for the active layer, the solar cells can be tuned to colourful aesthetic semi-transparent devices, which designers and architects can explore, e.g., for window designs. In this paper, we will try to enhance absorption in the active layers and thus efficiency of semi-transparent devices by using tandem bulk heterojunction solar cell architecture. We will have a look on two difference active layer as the first solution blend will be made of PCPDTBT (donor) and PCBM (acceptor), whose absorption peak is at the red-infrared part of the solar spectrum, while the second active layer will be made from P3HT (donor) and PCBM (acceptor), whose absorption peak is at the blue-green part of the spectrum. As the absorption ranges of these two active layers are complementary, the resulting absorption will cover a wider spectral range, enhancing the power conversion efficiency. At the same time, the semi-transparency of the solar cells will be optimized by controlling the thicknesses of the layers. To be sure that the solar cells are getting semi-transparent the electrodes must also be semi-transparent, and this will be made from ITO and from commercially available conductive polymers.

8-3

**Innovative nondestructive optical method for plant overall health evaluation**

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*In vivo* measurements of the optical properties of plant leaves, by spectrophotometric methods, could potentially provide very useful information considering plant's health. This research is focused on developing nondestructive optical processing method to obtain useful information for overall plant health evaluation. The analyses of the leaf spectroscopy (in the broad wavelength range) is well present in majority of the literature. The absorption spectra of chloroplast pigments provide clues to the relative effectiveness of different wavelengths for driving photosynthesis, since light can perform work in chloroplasts only if it is absorbed. This experimental procedure describes a novel experimental setup that enables continuous measurements of the optical reflection and transmission coefficients of broad-leaved plants. For each of 20 channels, the source of light is a red Signal LED with the spectral emission maximum at 665 nm. Special attention is given to the development of data collection software, as well as procedures for calibration of the measuring processing system and handmade methyl methacrylate leaf holders. Monitoring the evolution of the plant activity in real-time has resulted in the graph of the spectral Circadian rhythm as a function of time. Signatures from spectroscopic optical imaging could be successfully used to track nutritional disorders before visual symptoms are observed. The setup was tested on: *Ocimum basilicum* L. (the plants were grown in the hydroponics); *Phaseolus vulgaris* L., *Zea mays* L. (seeds were germinated in commercial humus), *Guzmania lingulata* (L.) Mez, *Vriesea carinata* Wawra, variegated *geranium* (L.) L'Hér. etc. The condition of the plants under test was assessed by the more common (destructive) methods such as: measurements of the determination of the photosynthetic pigment content, dry weight determination and the efficiency of PSII. Several biological parameters were observed, calculated and compared to the graphs of optical transmission dependence in real time. Currently, we are focused to update knowledge about fast and subtle changes in chloroplast movements during dark-light-dark transition and to relate different location of chloroplast to their photosynthetic capacity.

8-4

## 32Si Geochronometer: Radiochemical separation and purification of 32Si for half-life redetermination

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Radionuclide $^{32}$Si is a naturally occurring isotope that is produced in the atmosphere by cosmic rays and then precipitated via rainfall into the soil and sediments. With a half-life of 153(19) this radionuclide is considered to be one of the ideal geochronometers for radiometric dating for the period of 100 to 1000 years ago. So far, this time span has been hard to analyze by standard radiometric methods and radionuclides. Understanding climate patterns observed in the past leads to a better understanding of the climate changes we face today and the driving forces behind them. For $^{32}$Si to be used as a reliable radiometric tool and a geochronometer, it is extremely important to determine the exact half-life of this radionuclide with a very tight uncertainty rate, which hasn't been possible so far. The main reason why previous studies of $^{32}$Si half-life determination have had a large uncertainty and significant discrepancy between them is the low sample activity that was used in the studies. For this reason, the SINCHRON project has gathered several institutions from various countries in order to redetermine the $^{32}$Si half-life with a less than 5% uncertainty rate. Using the 590 MeV ring cyclotron available at PSI large activities of $^{32}$Si have been produced, radiochemicaly separated and purified. Production of $^{32}$Si was done by irradiating metallic vanadium discs with high energy protons and inducing spallation. A complex and robust radiochemical separation procedure has been developed at PSI for $^{32}$Si retrieval from irradiated discs. This procedure utilizes several separation steps based on ion-exchange and extraction resins. Radiochemicaly pure $^{32}$Si sample solutions with a high total activity (>20 MBq) have been produced this way and they represent world unique quantities of $^{32}$Si that will be used for metrological standard preparation in the future. Specific activities of the $^{32}$Si are several kBq/g and are more than enough for individual studies based on different methods (AMS, ICP-MS, LSC). Therefore, with such high quantities of $^{32}$Si it will be possible to perform half-life redetermination measurements with low uncertainty allowing $^{32}$Si to be used as a geochronometer.

8-5

**Early and non-invasive diagnosis of malignant and premalignant lesions of the mucosa of the oral cavity through imagistic methods**

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Neoplasic pathology is a permanent concern of the medical world. Early and accurate diagnosis and evaluation of oral lesions is a challenge for dentists. Early detection of these conditions is the strong point of improving survival by reducing the time of diagnosis. The purpose of this study is to detect early and non-invasive lesions in the oral cavity in order to obtain an accurate diagnosis leading to an ideal treatment plan to increase the chances of success.For this study, the OralID device was used for early and non-invasive detection of lesions in the oral mucosa. OralID is a battery-operated, hand-held oral examination light used as an adjunctive device for oral mucosal screening. OralID uses a proven, optically based technology called, "fluorescence technology." When the blue light from OralID shines on healthy oral tissue, it fluoresces green. However, when it shines on abnormal tissue, it appears dark due to a lack of fluorescence. During this evaluation, both the doctor and the patient use special glasses to protect their eyes. These glasses allow the doctor to visualize the fluorescent tissue during the medical examination. In this study, using oral ID, the entire mucosa of the oral cavity of patients was evaluated to determine whether or not various pathological lesions were present.Using the oral ID, the lesions of the oral cavity can be found early, in a simple, effective and non-invasive way, in a routine consultation, in order to obtain a diagnosis and treatment plan with the highest chances of success.

8-6

**Photography in dentistry - a new approach**

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Good photography is crucial in various dental areas. The clinical camera, if used correctly helps the practitioner not only to document its work pre and post treatment, but also to help improve patient education. What if there would be an easier and cheaper way to obtain high quality photos? The aim of this study is to observe to which extent a mobile phone can reach the performances of a professional clinical camera, but also to compare the photos taken by two different phones using different operating systems. For this study we used the camera of Iphone 13 pro and of Samsung S21 ultra. Regarding the professional clinical camera, Nikon Coolpix P900 has been used. For the pictures taken with the mobile phones, we used a dental photography kit containing mirrors, a contraster, retractors, and a twin flash. In this study, there were certain differences between the professional camera and the phone cameras observed. Although the professional clinical camera has some different features than the camera of the phone, it can be used in dentistry, obtaining great results.

8-7

**New concept in luting zirconia crowns**

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On the daily basis, the cementation of zirconia crowns is made with glass ionomer, or phosphate-based cements, which have shown that it can not guarantee a stable long-therme adhesion. In time the failure rate shown a procent of 3.1% chipping rate in 5 years and 14.5% chipping fracture in 5 years, in the basic Luting of Zirconia. The aim of this study is to understand the alternative way of improving the cementation of Zirconia crowns with magnetic nanoparticles. For this study were made 20 zirconia prostheses, for 20 teeth that were prepared for the cementation. The crowns have been placed on the abutments corectly and the ensemble have been sectioned in 2 equal halfs, group A and group B. Group A of 20 halfs of abutments were luted with classic glass ionomer cement. Group B of 20 halfs of abutments were luted with optimized glass ionomer with magnetic nanoparticles, while a permanent magnet was positioned in the sectioned areea of the tooth. On the both groups there were performed X-ray and microscopic investigations in order to evaluate the luting interface. The imagistic evaluations showed a diminished luting interface in group B in compare with the group A. Nanomagnetic particles luting optimized glass ionomer could act as a possible option for cementation procedure.

9-1

## Electrodeposition of Ni-Sn alloys on porous Ni substrates as Hydrogen evolution catalysts

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Ni based materials are widely used as cathodes in alkaline water electrolysis. The optimal materials for use in zero-gap flow electrolysers, that are regarded as state of the art industrial technology for hydrogen production should have a 3D porous structure for the efficient gas diffusion and electrolyte flow. In this research we have investigated the electrodeposition conditions, as a coating procedure for the production of the high performance Ni-Sn catalyst at Ni foam substrates. In order to reach optimal deposition parameters suitable for scale up proces, we have employed different procedures such as linear sweep voltammetry, controlled potential coulometry and chronopotentiometry to deposit the Ni-Sn alloys of optimal coating thickness and composition. When galvanostatic conditions were employed, different deposition current densities were applied to reach the electrodes with exceptional hydrogen evolution overpotential around -100 mV at – 1 A $cm^{-2}$, normalized per geometric area, in 1 M KOH at room temperature.

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9-2

**Satellite structured boride reinforced In718 based composite powder preparation for additive manufacturing**

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Ni-based superalloys such as In718, are advanced engineering materials that are especially used for high temperature applications due to their supperior strength at high temperature, creep resistance and oxidation resistance. However, improved material properties are required for higher energy efficiency and lower specific fuel consumption. One of the ways to improve the properties of Ni-based superalloys is introduction of harder and stiffer ceramic particulate reinforcements. Traditionally, ceramic particulate reinforced metals/alloys are known as metal matrix composites (MMCs) which can exhibit enhanced hardness, strength, corrosion ressistance, etc. For the In718 superalloys, similar design concept can be utilized to obtain even better material properties. Powder metallurgy (PM) is a technique to produce MMCs, which generally involves ball milling and sintering to reach final materials. However, additive manufacturing became a more interesting method to produce material parts with near-net shape using powder based materials for feedstock. In this study, sub-micron sized boride particulates ($CrB_2$, $ZrB_2$ $TiB_2$ $HfB_2$ $LaB_6$) are decorated around the spherical In718 powders with high-energy ball milling/mixing equipment at low durations. The boride reinforcement materials are used in 2 wt% quantities at overall powders. The SEM analyses are conducted to observe the powder morphology after mixing and it is clear that the sphericity of the In718 powders are retained. Energy dispersive spectroscopy (EDS) mapping analyses are completed to see the elemental distribution. As a result, satellite structured In718 superalloy based composite powders are produced which are suitable for further additive manufacturing.

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9-3

**Composite coatings based on Zn-Co alloy and yttrium/samarium with the self-healing effect of substrate**

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Self-healing coatings are the type of so-called smart coatings, whose main feature is the ability to detect and repair damage caused by penetration of corrosion agents into the metal substrate. It is well-known that lanthanides have inhibition properties, and that cerium-based composite coatings, obtained by the electrodeposition method, have shown excellent self-healing activity. The aim of this thesis is the examination of composite coatings based on Zn-Co alloy and various lanthanoids as the source of the secondary phase: samarium and yttrium, with the concentration of 2 and 5 g $dm^{-3}$, in order to determine whether they contain a self-healing effect. The electrodeposition of coatings is done from chloride solutions, galvanostatically, in the range of current densities 1–8 A $dm^{-2}$, using the magnetic stirrer, at the speed of 300 rpm, on the steel cathode (AISI-1010) and using a high purity zinc anodes. The corrosion resistance of deposited coatings is examined by the method of electrochemical impedance spectroscopy (EIS) in a 3% NaCl solution. The morphology of the sample surfaces was analyzed by scanning electronic microscopy (SEM), and chemical composition with energy-dispersive X-ray spectroscopy (EDS), which indicates that the alloys are obtained by the anomalous type of deposition. It was shown that with the lower density of the deposition current a larger amount of particles (samarium or yttrium) is embedded in coatings, and a higher potassium content was observed in the case of samarium-based coatings. All of the examined composite coatings have had higher corrosion resistance than binary Zn-Co alloy, and the level of protection depended on the type and quantity of incorporated particles, as well as the morphology of obtained coatings. The yttrium-based protection systems, deposited on lower current densities, have shown exceptional corrosion resistance, better even than cerium-based coatings, as well as a self-healing effect. These coatings could be an adequate replacement for the conventional Zn and Zn-alloys coatings.

9-4

## Influence of cold deformation on the hardness and electrical conductivity of the EN AW-7075 aluminum alloy

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An experimental investigation was carried out on the commercial aluminium alloy EN AW-7075. The study included changes in the hardness, as well as changes in electrical conductivity as a function of deformation degree. Before deformation, annealing of the samples was done at 480°C for 3 hours, followed by air-cooling. This was done in order to remove as fabricated state and to obtain annealed state (Temper O). After annealing, the cold rolling was carried out in amount of 15% - 45%. Hardness and electrical conductivity were investigated after each step in the experiment process. The results show an increase in hardness values with the increment of deformation degree. Values of electrical conductivity decrease with the increase in deformation degree. The highest values of hardness and the lowest values of electrical conductivity were obtained with the highest deformation degree. The metallographic investigation shows that the particles of equilibrium phases obtained after annealing and deformation are oriented in the rolling direction.

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9-5

**Hybrid polymer composites epoxy/PVB reinforced with sub-micron and nano-sized BN**

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Recent development of composite materials was oriented towards finding high-performance reinforcements and finding appropriate ways of their incorporation in various matrices. This research considers application of boron nitride, BN, in form of sub-micron and nano-sized reinforcing filler for a hybrid polymer matrix system combined of epoxy resin and poly(vinyl butyral), PVB. PVB is known to improve the ductility and toughness of epoxy resin. The combination of PVB with epoxy has been chosen in order to achieve good adhesion to many engineering materials, for future application in structural composites, in different laminates or sandwich structures. As a ceramic material, boron nitride has been chosen due to its extraordinary mechanical strength and high hardness, as well as thermal and chemical resistance. Hybrid polymer composites samples with and without boron nitride nanoparticles were made by solvent-casting technique. BN was ultrasonically dispersed in ethanol, PVB powder Mowital B45H was added and mixed until dissolved, and finally mixed with epoxy resin EpicoteTM Resin MGSR LR 385 with EpicureTM CuringAgent MGSR LH 385. Small concentrations of BN were used, 0.5wt% and 1.0 wt.%, in two different grades: nano BN 70 - 80 nm and sub-micron BN 200 nm. FTIR/ATR analysis was applied to investigate any chemical interaction between the constituents of the composite samples. Mechanical performance was examined trough tensile test and hardness measurement. The addition of nano reinforcements, tensile test has resulted in the improvement of the maximum tensile force, especially with the smaller nanoparticles, and better results were observed with lower concentration of the filler. An increase in the Shore hardness values was observed for both grades of BN in both concentrations. The achieved improvements of the mechanical resistance are a consequence of physical interactions of the BN particles with the hybrid polymer matrix. The new BN reinforced polymer system might find potential application in aircraft constructions, automotive, naval, and defense industry, in civil engineering, etc.

9-6

**Optimization studies on powder preparation of SiC nanowire and SiC/$ZrB_2$ particulate reinforced In718 powders for additive manufacturing**

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In this study, the effect of reinforcement type and mechanical alloying (MA) duration on the microstructural properties of reinforced inconel 718 (In718) particles were investigated in detail for potential usage in additive manufactiring studies. Both SiC nanowires and SiC/$ZrB_2$ particles were used as reinforcement materials for In718 powders to determine the effect of reinforcement type. SiC and $ZrB_2$ particles (<325 mesh) were milled for 4 h to synthesize their nano-scaled particles. Powder blends that contained In718 powders (98 vol.%) and various reinforcements (2 vol. %) were prepared. Powders blends were loaded to the milling vials in glovebox under argon (Ar) atmosphere. First, as-blended In718-2 vol.% (SiC nanowires) powders were mixed using high energy ball-mill (1200 rpm) for 30 min, 2 h, 4 h and 6 h. Secondly, as-blended In718-2 vol.% (SiC/$ZrB_2$ nanoparticles) powders were mixed 30 min. to investigate the effect on morphology which is suitable for additive manufacturing or not. X-ray diffractometer analysis (XRD) were conducted for phase determinations. Additionally, scanning electron microscopy (SEM)/electron dispersive spectrometry (EDS) analysis were performed for detailed morphological characterizations. As a result of microstructural characterizations, 30 min milled both SiC nanowires and nanoparticles reinforced In718 powders were suitable for additive manufacturing applications due to their spherical morphologies.

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9-7

## Infrared and Raman study of narrow-gap semiconductor $FeGa_3$

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Narrow-gap semiconductors have been intensively studied in the last few years due to their huge thermoelectric power at low temperatures and possible impact of strong electronic correlations on their physical properties. Here, we analyse infrared and Raman spectra of $FeGa_3$ single crystal. The optical conductivity obtained from reflectance measurements suggests an indirect energy gap of around 0.4 eV, although the existence of substantial spectral weight at low energies prevents its precise determination. The energies of Raman and infrared active modes obtained by our DFT calculations agree very well with the experimental results. Temperature dependence of Raman mode energies and linewidths is weak between 80 and 300 K, indicating the absence of any phase transition. Most of the vibrational modes are very narrow due to weak electron-phonon and/or spin-phonon interactions, and good crystallinity of the single crystal, which is also confirmed by the Mössbauer spectra.

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9-8

## Applying electrically conductive hot melt copolyamide in the additive manufacturing process

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Among different methods of additive manufacturing, Fused Filament Fabrication (FFF), also known as FDM, is the most commonly used and cost-effective way to produce 3D complex shapes with various types of thermoplastic polymers. The new approach includes the fabrication of filaments that possess new functionalities, e.g., electrical conductivity. Such filaments can contain multiple types of conductive fillers like carbon nanotubes, carbon black, graphene or metal powders, while the main matrix used is polylactic acid (PLA), thermoplastic polyurethane (TPU), acrylonitrile butadiene styrene (ABS) or polyethylene terephthalate modified with glycol (PETG). In this work, a filament with 1.75mm was fabricated from a special type of thermoplastic polymer- hot melt copolyamide and multi-walled carbon nanotubes using a twin-screw extruder. The composite filament's thermal, mechanical, and rheological properties were characterized and correlated with the dispersion of the carbon nanotubes investigated by tomography technique and high-resolution microscope. It allowed optimizing the printing conditions of this novel conductive filament. Its printability was validated using Prusa i3 MK3S+ and changing the nozzle temperature to analyze its effect on the electrical conductivity. For the comparison, the commercially available filaments based on PLA, PETG, and ABS were tested using the same approach.

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10-1

**Evaporation of polonium from LBE-cooled reactors**

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The use of liquid metals such as lead-bismuth eutectic (LBE) as a coolant is a potential development path for generation IV nuclear power reactors. This type of reactor is primarily intended for use as breeder reactors or for the transmutation of nuclear waste, thus closing the nuclear fuel cycle.LBE exhibits a variety of interesting characteristics. It has excellent thermal properties, exhibits a low vapor pressure and high boiling point in addition to its ability to shield of γ-radiation. In order to use it as a coolant, the distribution and behaviour of radionuclides within LBE are of the utmost importance for evaluating the safety aspects of such systems. To make accurate predictions, the release of radionuclides from the coolant must be well understood, particularly for potential accident scenarios. Within the HORIZON2020 project PATRICIA, previous research on the volatilization of radionuclides from LBE that is pertinent to the safety of future accelerator-driven systems is continued. In particular the volatility of polonium is investigated, since it represents one of the most radiotoxic and volatile radionuclides formed during the operation of such reactors. Here, we describe the latest results regarding the volatilization studies of polonium from MEGAPIE employing the transpiration method.

10-2

**3D electrodes for industrial alkaline flow electrolysers**

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The need for energy produced by clean technologies using renewable sources has become the crutial point for the further development of the society. If produced by water electrolysis using renewable sources (sun, wind, hydropower, etc.) hydrogen can be regarded as an energy carrier. Production of hydrogen by alkaline water electrolysis in zero-gap flow electrolysers is the most commonly used system on industrial level, given that non-precious abundant metals (such as Ni and Fe) can be used as efficiant and stabile cathods in the form of 3D porous structures such as metal foams. In this research, Ni foam with open-pore structure and average pore size of 450 μm was used as cathode material, as well as Ni-Sn coated Ni foam, and their performance for hydrogen evolution was compared in 30% KOH at 70˚C in H-cell. In addition, the coated foams that have demonstrated superior activity then commercially used bare Ni foams, were tested in a zero gap flow electrolyser with Ni based materials with different porosity used as anodes. The lowest achieved cell voltage was 1,85 V at -50 A $dm^{-2}$ wich is in line with the benchmark systems.

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10-3

**Hybrid aqueous Ca-ion battery: Design and Performance**

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Moving toward the commercialization of safe and sustainable energy storage systems, the research on aqueous rechargeable batteries (ARBs) becomes more intensive. Moreover, development of alternative ARBs based on more abundant and sustainable element chemistry (Na, Mg, Ca, and Zn) has received significant attention. Great efforts for their development started to pay off when an aqueous sodium battery ($NaTi_2(PO_4)_3$//1 M $Na_2SO_4$//$Na_{0.44}MnO_2$) appeared on the market alongside organic rechargeable batteries. In this study, a hybrid full-cell aqueous configuration was made from biomass-derived activated carbon (anode), 5 M aqueous solution of $Ca(NO_3)_2$ (electrolyte), and layered $CaV_2O_6$ (cathode). A high surface area carbon was synthesized by the simultaneous carbonization and activation of vine shoot-derived biochar at 700 °C under Ar atmosphere (ACvs). $CaV_2O_6$ composite with the carbon (CaVO/C) was obtained by the sol-gel complexation method. The charge storage behaviour of ACvs and CaVO/C materials was investigated in the aqueous solution of 5 M $Ca(NO_3)_2$ and showed promising results. Not only do materials individually exhibit good electrochemical behaviour, full-cell configuration ACvs700//5 M $Ca(NO_3)_2$//CaVO/C displayed improved charge storage (89 mAh $g^{-1}$ at 100 mA $g^{-1}$) in comparison to mentioned commercial aqueous $NaTi_2(PO_4)_3$//1 M $Na_2SO_4$//$Na_{0.44}MnO_2$ model (≈50 mAh $g^{-1}$ at ≈100 mA $g^{-1}$). These results enrich the existing hybrid aqueous battery design and open up a new research era for Ca-ion batteries.

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10-4

**Epitaxial growth of metal oxide thin films on semiconductors**

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Epitaxy represents a type of crystal growth or material deposition in which new crystalline layers are formed with one or more well-defined crystallographic orientations with respect to the seed layer. The epitaxy is usually implemented in the cases when new functionality is to be integrated with the already present platform. The two methods for the epitaxial growth of thin films *i.e.* pulsed laser deposition (PLD) and ion beam assisted deposition (IBAD) will be compared. We will highlight the most important aspects of the epitaxial growth of metal oxides (MO) on semiconductor (SC) substrates, including processes in the vapor phase and at the MO/SC interface. We will describe how the growth parameters (temperature, partial pressure, deposition rate, *etc.*) can affect the stoichiometry, morphology and overall crystalline structure and properties of the MO thin film. The important properties of MO and MO/SC interface will be also highlighted from the point of view of photoelectrochemical water splitting. Beside the growth parameters, the role of ion beam irradiation in tuning of physical and chemical properties of the MO and SC will be also discussed. The selection of appropriate characterization methods (surface and bulk) will be also highlighted for monitoring the growth of MO and the processes relevant in photoelectrochemical water splitting. An outline of the first experiments to be performed will be also presented.

10-5

**PbSe targets for nuclear physics studies**

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A methodology for the production of PbSe targets for $^{79}$Se neutron capture cross section studies is here presented. PbSe material was synthesized by direct reaction of its constituents at high temperature. The produced PbSe was then purified with a gas-phase method, and the material was then characterized by X-ray diffraction. After the synthesis of the pure PbSe material, thin PbSe targets were prepared by applying a physical vapor deposition technique. The morphology and composition of these films (400 nm in thickness) were analyzed by X-ray fluorescence, Scanning Electron Microscopy, and Energy dispersive X-ray spectroscopy. These targets were prepared for cross section experiments with the surrogate reaction method. Then, a second target was produced for cross section measurements with the Time-of-Flight method at CERN in Genève. These radioactive Pb$^{79}$Se targets were produced by neutron irradiation at ILL, France. The targets were characterized by γ-ray spectroscopy. Finally, a procedure for the extraction and recovery of Se from PbSe is suggested. The efficiency of the chemical separation was quantified by γ-ray spectroscopy. For the scope, radioactive $^{75}$Se was used as a tracer. The purity of the retrieved Se was instead determined with Inductively Coupled Plasma Optical Emission Spectroscopy.

10-6

## Carbon felt/PPy-functionalized/AgCl composite as cathode material for rechargeble Mg cell

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Carbon felt functionalized with galvanostatically synthesized polypyrrole was used as a substrate for the formation of CF/PPy- AgCl electrode. AgCl was deposited by the application of the SILAR method. The electrochemical behavior of the as-synthesized composite was evaluated through cyclic voltammetry and charge-discharge techniques. Experimental results show the great potential for the usage of composite CF/PPy- AgCl as cathode material in rechargeable aqueous-based Mg cell. In the current range of 135 to 1350 A $g^{-1}$, the specific capacity in the range of 35 to 25 Ah $kg^{-1}$, the energy of 45 to 25 Wh $kg^{-1}$, and power of 100 to 1600 W $kg^{-1}$ are obtained for the potential rechargeable aqueous AZ63 |3.5% NaCl |CF/PPy-AgCl cell. Additionally, the cyclic stability is assessed, and it is concluded that, depending on the mass of the magnesium alloy, such a simple cell may be charged at least 100 times. The potential for additional system improvement is taken into account. Future work concerns the way of improving the cycling stability of cathode material.

10-7

**Synthesis and characterization of Al-x($Hf_{0.2}Ti_{0.2}Zr_{0.2}V_{0.2}Nb_{0.2}$)$B_2$ (x = 1, 2, 5, 10, 15 wt.%) composites**

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In this study, Al-x($Hf_{0.2}Ti_{0.2}Zr_{0.2}V_{0.2}Nb_{0.2}$)$B_2$ metal matrix composites were synthesized using planetary ball milling assisted spark plasma sintering (SPS) and high-energy ball milling/pressureless sintering techniques. Firstly, all boride powders were produced via mechanochemical synthesis (MCS) and leaching starting from metal oxide, magnesium and boron oxide powders in the lab-scale systems. Then, these borides were prepared at equimolar ratios and milled in a planetary ball mill for 72 h. During planetary ball milling, tungsten carbide balls and vials were used and the ball-to-powder weight ratio (BPR) was choosen as 10:1. After milling, mechanically alloyed powders were sintered with spark plasma sintering method at 2000°C under 30 MPa. The sintered high entropy ($Hf_{0.2}Ti_{0.2}Zr_{0.2}V_{0.2}Nb_{0.2}$)$B_2$ boride ceramic was crushed into powder and added to the aluminum (Al) matrix powder. "x" represents weight percent compositions and it ranges from 1 to 15. Also, 2 wt.% stearic acid was added as a process control agent. Later on, the Al-high entropy boride powder blends were milled for 6 h in a Spex 8000DMixer/Miller. During milling, hardened steel balls and vials were used and the BPR was choosen as 7:1. After milling, powder blends were cold pressed, debinded (420 °C, 1 h) and pressureless sintered (630 °C, 2 h). Phase identifications of both powders and sintered samples were carried out by using an X-ray diffractometer. Additionally, density measurement was performed using both Archimedes' and pcynometer methods. Mechanical properties of sintered samples were determined using Vickers microhardness tester under 100 g and using dry sliding wear tester.

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10-8

**Screening for novel bioconverters of animal husbandry wastes into valuable substances**

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Conversion of protein-containing agricultural waste into vauable substances (food and feed, fertilizers, biomaterials, etc.) is a perspective amd green approach to waste disposal. Ehe most complex, but promising substrates are fibrillar proteins, found in bristles, feathers, ligaments, etc. Bioconversion is a novel green approach consisting in cultivation of bioconverting agents on waste matter, followed by specific and determined decomposition of the substrate for further use. In this work, 17 strains of *Aspergillus* fungi were assessed as potential bioconverters. First, pre-culture was obtained after 48 hours of cultivation on carbohydrate-rich medium. Then, the biomass was transferred to liquid medium, containing non-specific inductor of proteolysis (fish flour hydrolysate) and cultivated for 96 hours. For culture liquid, elastinolytic, keratinolytic, collagenolytic and general proteolytic activity were measured spectrophotometrically. Later on, the dynamics of proteolytic enzymes' accumulation was studied for the four most active strains, followed by cultivation of a selected strain with different specific inducers (collagen, elastin, feather meal, keratin hydrolysate, wool), and without one. After 48 hours of cultivation, the same activities were measured. The preliminary screening indicated four potential bioconverting strains: *A. aureolatus*, *A. creber*, *A. jensenii*, *A. tabacinus*. For every strain the peaks of general proteolytic and keratinolytic activities are observed after 96 hours of cultivation (except *A. aureolatus* and *A. jensenii* with keratinolysis peaks at 72 hours of cultivation). *A. aureolatus* was taken for further research and cultivated with specific inducers and without any. When being cultivated without inducer, *A. aureolatus* exposed high general proteolytic activity (33.15 $U_{azc}$), which indicates a presence of constitutive non-specific protease. When growing on keratin-containing media it did not show distinguished keratinolytic activity. However, being cultivated on collagen and elastin, this strain exposed high keratinolytic and collagenolytic activities (27.20 $U_{ker}$ and 26.60 $U_{coll}$, respectively), which demonstrates its potential as a bioconverter of waste fibrillar proteins into valuable biomaterials.

11-1

## Heterojunctions based on g-$C_3N_4$ for the photocatalytic reduction of Cr(VI)

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A potential visible light photocatalyst, metal-free graphitic carbon nitride (g-$C_3N_4$) has attracted great attention as a green photocatalyst due to its simple preparation, high stability, low cost and medium band gap of about 2,7 eV. Nevertheless, high recombination rate of electrons and holes and small specific surface area limit its practical application. To improve certain properties and use the good ones of g-$C_3N_4$, different types of modifications have been used including doping, deposition or sensitization with various ions, noble metals, semiconductors or other materials. In this work, g-$C_3N_4$ was produced from urea by simple pyrolysis process and was modified by depositing $TiO_2$ and/or carbon quantum dots (CQD) in order to form heterojunctions, including so-called "Z" scheme. CQDs were deposited by decomposition of citric acid in hydrothermal conditions (samples CQD-$C_3N_4$ and CQD-$C_3N_4$-$TiO_2$)) and $TiO_2$ by modified sol-gel method (samples $C_3N_4$-$TiO_2$ and CQD-$C_3N_4$-$TiO_2$). The properties of the obtained photocatalysts were studied by FESEM, FTIR, BET and DRS analysis. Photocatalytic reduction of Cr(VI) was tested at a constant initial solution concentration (10 mg/l), at pH=3 or pH=6, under the simulated visible irradiation. The concentration of Cr(VI) after irradiation was determined by UV-Vis spectroscopy. Obtained results showed that the modified photocatalysts provided significantly higher photocatalytic efficiency under the visible light compared to pure g-$C_3N_4$.

11-2

## $TiO_2$ nanoparticles supported on natural zeolite clinoptilolite from Serbia for removal of bisphenol A from aqueous solution

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Bisphenol A (BPA) is a well-known emerging contaminant that pose a severe threat to human health due to its negative effect on the body's endocrine systems. BPA is widely used in the production of polycarbonate plastic and epoxy resins and therefore often detected in different water environments. Since the conventional wastewater treatments for BPA removal haven't been proven efficient it is important to find a green and efficient method for its complete elimination. Therefore, the aim of this work was to prepare a cost-effective hybrid photocatalyst based on $TiO_2$ nanoparticles and natural zeolite clinoptilolite and study its photocatalytic performance toward BPA. The $TiO_2$/clinoptilolite, containing 20 wt% of $TiO_2$, was prepared using ultrasound assisted solid-state dispersion method and characterized using a multi-technique approach by combining X-ray powder diffraction, FTIR, UV Vis DRS spectroscopy, atomic force microscopy (AFM), BET measurements and laser diffraction. The study showed complete removal of BPA (5 mg/L) after 180 minutes of simulated solar irradiation using 2 g/L of hybrid photocatalyst, at pH = 6.4. The addition of $H_2O_2$ led to a faster BPA removal after 120 minutes of irradiation. When BPA removal was tested in bottled drinking water a lower removal of 60 % after 180 minutes of irradiation was observed because of the presence of bicarbonate ions and its scavenger effect toward hydroxyl radicals. The reused photocatalyst showed good photocatalytic activity in repeated cycles (e. i. 70 % of BPA was still successfully removed at the end of the $4^{th}$ cycle).

11-3

## Synthesis of biomorphic $TiO_2$ and its photocatalytic activity in the removal of amitriptyline and ciprofloxacin from the aqueous medium

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As a tricyclic antidepressant, amitriptyline (AMI) inhibits the reuptake of the neurotransmitters noradrenaline and serotonin from the synapses of the central nervous system. Ciprofloxacin (CIP) is a fluoroquinolone antibiotic that exhibits activity against aerobic, anaerobic and facultative anaerobic Gram-positive and Gram-negative bacteria. Over the last few decades, the focus has been set on monitoring the increased presence of various active pharmaceutical ingredients (APIs) in the environment. APIs, such as AMI and CIP, can reach the aquatic environment via municipal wastewater, resulting in their appearance in drinking water. This may have a damaging impact on aquatic organisms, as well as human health. Therefore, great efforts to remove APIs using eco-friendly processes are being made. Photocatalysis is an advanced oxidation process that occurs under mild experimental conditions that lead to the production of highly reactive hydroxyl radicals which can oxidize and mineralize organic pollutants to harmless products, namely $CO_2$, $H_2O$, and corresponding inorganic ions. The term biomorphic refers to a template that resembles a living organism in shape and appearance. Uniform morphology and particle size, surface texture, environmental friendliness and availability are just some of the desirable properties possessed by biological templates. The aim of this work was the synthesis of biomorphic $TiO_2$ with black alder pollen by the impregnation process, including the study of its photocatalytic activity in the removal of AMI and CIP from the aqueous medium using ultraviolet radiation or simulated sunlight. Newly synthesized photocatalyst was characterized with scanning electron microscopy with energy dispersive X-ray spectroscopy and X-ray diffraction. The removal kinetics of AMI and CIP was monitored by ultra-fast liquid chromatography.

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11-4

**Modified food wastes as potential sorbents for phosphate removal**

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Annually, around 1.4 billion tonnes of food worldwide is classified as waste. This waste, usually disposed at landfills, poses a serious threat to both the environment and human health. With appropriate modifications, food waste can be converted into value-added products for the removal of organic and inorganic contaminants from aqueous solutions. In this study food waste (peach, cherry and plum stones) were modified with $MgCl_2$ and pyrolyzed to produce biochar, a multifunctional highly porous carbon rich material with improved properties for phosphate ($PO_4^{3-}$) removal. The samples were categorized using the Fourier transform infra-red (FTIR-ATR) technique, point of zero charge ($pH_{pzc}$) and pH suspension ($pH_{sus}$). The experimental sorption results revealed that the modified plum stone biochar (PSB-M) has higher sorption capacities than other materials. Kinetic adsorption experiments demonstrated that the pseudo-second-order model was the most suitable one for $PO_4^{3-}$ adsorption on PSB-M. The production of such a sorbent can be affordable considering that the raw material is regarded as waste. Therefore, the findings of this research can be a foundation for the synthesis of an effective phosphate sorbent, whose properties and maximum sorption capacity should be further researched.

11-5

**Sustainable removal of 17α-ethynilestradiol from aqueous environment, using newly synthesized ZnO-based nanocomposites**

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Recently, the presence of emerging pollutants (e.g. pharmaceutically active compounds) in the environment has been intensively increased. Currently, over 2 billion people are exposed to the effects of contaminated water and live in water-stressed countries, which are expected to be more exacerbated. The inefficiency of the generally applied water treatments additionally adds up to the pollution level of waters. Heterogeneous photocatalysis is a sustainable and efficient alternative for the conventional techniques. This process is based on the interactions between adequate light radiation (e.g. sunlight) and semiconductors, as photocatalysts. The main drawback of this process is that the commercial photocatalyts (e.g. $TiO_2$ or ZnO) have limitations due to their high bandgap energy. Hence, innovative, green and effective materials should be developed to overcome this issue. The nanomaterials, with their unique properties, are adequate alternatives for the abovementioned semiconductors. In this study the efficiency of the newly synthesized ZnO/MgO, $ZnO/CeO_2$ and $ZnO/ZrO_2$ nanoparticles, prepared by mechanochemical method in a molar ratio of 2:1, was investigated in the removal of 17α-ethynilestradiol (EE2) from water suspensions, under simulated solar irradiation. Furthermore, additional experiments were carried out to examine the effects of catalyst loading and initial pH value on the photocatalytic activity. Based on the obtained results it can be concluded that all newly synthesized nanocomposites showed an acceptable removal rate of EE2. The highest photocatalytic activity was observed in the system using $ZnO/ZrO_2$, with catalyst loading 1.0 mg/mL and initial pH ~8, when 90% of EE2 was removed after 120 min of irradiation.

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11-6

## Onion peels as an adsorbent for copper ions biosorption – Kinetic and thermodynamic studies

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The kinetic and thermodynamic studies of the copper ions biosorption process using onion peels as an adsorbent are presented in this paper. The experimental data were modeled using the following kinetic models: pseudo-first order kinetic model, pseudo-second order kinetic model, intraparticle diffusion kinetic model, and Elovich kinetic model. Analysis of the obtained data for the above-mentioned kinetic models indicated that the pseudo-second order model showed the best agreement with the modeled experimental data, with the correlation coefficient $R^2$ = 0.994. Such results led to the conclusion that chemisorption could be a possible mechanism for binding the copper ions to the surface of the onion peels. The influence of temperature on the adsorption capacity of onion peels was investigated. Obtained experimental data was used to calculate the thermodynamic parameters. The change in Gibbs free energy suggested that the copper ions biosorption onto onion peels is favored at lower temperatures. High activation energy (Ea) indicated that chemisorption was potentially the dominant mechanism of binding the copper ions onto the onion peels. The changes in pH and conductivity during the rinsing of the adsorbent as well as during the biosorption process were also monitored. The pH value increased during the rinsing of the adsorbent, as a result of the transfer of $H^+$ ions from the aqueous phase into the structure of the onion peels, where they were exchanged with alkali and alkaline-earth metal ions. In the first phase of the rinsing process, the increase in conductivity value occurs due to the transfer of alkali and alkaline-earth metal ions from the structure of the onion peels into the aqueous phase. With further rinsing, a decrease in conductivity occurs due to dilution of the solution. A rapid decrease in the pH values was noted in the first 10 minutes of the biosorption process. This rapid drop in pH value in the initial period occurred due to the deprotonation of functional groups within the structure of the onion peels and the transfer of hydrogen ions into the solution. A sudden increase in conductivity was noted during the first 10 minutes of the biosorption process, as a result of the increase in the concentration of alkali and alkaline earth metal ions in the solution. Alkali and alkaline-earth metal ions were transferred from the structure of the adsorbent into the aqueous phase, where they were exchanged with copper ions.

11-7

**Ultra-high performance fiber reinforced concrete for applications in complex building structures**

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This paper describes the key elements of the results of laboratory research on the resistance of high-performance micro fiber-reinforced concrete (composite material) to impact, dynamic loading and to the occurrence of crack propagation due to such loading. Laboratory research was conducted in order to develop high-performance micro fiber-reinforced concrete (FRC) in order to use it in the production of the primary lining of a funnel-shaped structure that is subjected to impact loads. For research purposes, a type of concrete with the same matrix was made for all samples (aggregate, cement, water and additives), and three different types of steel fibers were added to it in amounts of 1%, 2%, 3% in the total mass of concrete. The selected steel fibers, as well as the amount of fibers used, greatly influenced the improvement of the physical and mechanical characteristics of high-performance micro fiber-reinforced concrete. By adding steel fibers to concrete, a significant increase in energy is achieved, which prevents and temporarily delays the appearance of the first crack in the mass of concrete, which is presented in detail by within this paper.

11-8

## Decolorization of azo dye Methyl Orange with crude fungal laccase obtained by growing *Ganoderma spp.* on cereal mix

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In recent years, one of the biggest environmental problems is the pollution of water with colored wastewater which has negative effect on the environment and human health. Wastewaters contain complex structural compounds, such as azo dyes that used today in many industrial fields. Removing of azo dyes from wastewater using traditional methods is an extremely complex and, in many cases, ineffective process. In recent decades, there is a tendency towards the application of environmentally acceptable methods of removing synthetic dyes from wastewater. Method which has proven to be very effective, is the degradation of synthetic dyes using various fungal enzymes. In this study, the crude fungal laccase (31,42 $UmL^{-1}$) obtained by growing fungal mycelium *Ganoderma spp.* on cereal mix was used for decolorization of Methyl Orange. Decolorization procedure was carried out at different temperatures (30-70 ºC) and pH (3-8) in order to determine the optimal conditions for dye decolorization. The incubation time was 180 min and every 15 min during the incubation time, the change in color intensity was monitored spectrophotometrically at 472 nm and decolorization efficiency (DE) was calculated. The optimal pH was 5 with DE of 57 % at 30 ºC, while in the case of other pH values, DE was lower. The lowest DE (1,2 %) was in the case of pH 8, which indicates that laccase activity decreases in the alkaline medium. The optimal temperature of decolorization was 50 ºC with DE of 62 % at pH 5, while the DE was lower at higher and lower temperatures, which is in accordance with the literature data on the laccase activity optimal temperature of the *Ganoderma spp.* The lowest DE was 35 % at 70 ºC and pH 5. The obtained results show that laccase with good decolorization properties can be obtained using cheap agro-industrial wastes, such as cereal mix. The low cost of laccase production as well as the relatively high DE in a short time may further broaden its application in wastewater treatment.

12-1

**Pyrimethanil cytotoxic activity on human testicular teratocarcinoma NT2/D1 cells**

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Even though fungicides represent potentially harmful agents for the environment and the living organisms they make more than 35% of the pesticide market in the agricultural sector worldwide. Due to fungicides potential biological accumulation in the environment it is important to evaluate their toxic effect to environment and humans. Pyrimethanil (4,6-Dimethyl-N-phenyl-2-pyridinamine) is a synthetic fungicide used to control pre- and post-harvest crops diseases, particularly in fight against *Botrytis cinerea*, necrotic fungus which commonly damages grapes. Since pyrimethanil is a suspected human carcinogen the US FDA and EU have established its maximum permissible level (5 μg/mL) in finished wine. Since mechanism of pyrimethanil cytotoxic activity are not fully elucidated, our study evaluates its toxic potential by testing cytotoxicity, oxidative stress and apoptosis in human testicular teratocarcinoma NT2/D1 cell line. Our study showed a reduction in cell number accompanied with significant morphological changes characteristic for apoptosis. Also, pyrimethanil management resulted in an increase in production of reactive oxygen species in NT2/D1 cells and induced apoptosis that led to cell death. Further, we have detected increased expression of two well-known hallmarks of apoptosis, p53 and cleaved Caspase-3. To gain a deeper understanding of fungicide effects on human health and environment it is important to know mechanism of toxicity. Presented results suggest that fungicide pyrimethanil has strong cytotoxic effect on cells *in vitro* and exerts oxidative stress-promoted action via the apoptotic pathway. Additional studies are needed in order to further clarify molecular mechanisms and to assess the overall relationship between benefits and potential harms of pyrimethanil on human health, as well as on environment.

12-2

**An assessment of tritium deposition on the earth's surface**

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Tritium, radioactive isotope of hydrogen, is produced naturally in the upper atmosphere between nitrogen atoms with high energy cosmic rays. Anthropogenic production has disturbed the natural levels of tritium by nuclear atmospheric tests between 1945 and 1963. Tritium is a pure beta emitter with half-life of 12.32 years. Since the main way to eliminate tritium from the atmosphere is through precipitation, whether of natural or artificial origin, tritium easily reaches surface waters and soil from where it can infiltrate into the groundwater and thus enters in the hydrological cycle. Accordingly, knowing the concentration of tritium in precipitation is of essential importance. This paper presents determination of tritium in precipitation collected at Reference Meteorological Station Zeleno Brdo in Belgrade during 2019. Analysis is done in composite monthly samples. Sample preparation involves the first distillation, electrolysis and the second distillation. Samples were measured by Liquid Scintillation Spectrometer Quantulus 1220 after electrolytic enrichment by mixing 8 ml of sample with 12 ml of scintillation cocktail. Tritium activity concentration in analyzed precipitation samples follows normal seasonal variations with maximum in spring-summer months. Based on the monthly amount of precipitation, that is available on the website of the Republic Hydrometeorological Servise of Serbia, it is possible to estimate the deposition of tritium on the earth's surface. The wettest months of 2019 were May and June, and since tritium concentrations are the highest in these months (June: 2.89 Bq/l), the highest value of deposited tritium is obtained in June: 400,8 Bq/m$^2$. In accordance with the legislation in the Republic of Serbia, the permitted values of tritium are defined only for drinking water (100 Bq/l). An elevated tritium level may indicate the presence of other artificial radionuclides. If an increased activity of tritium is detected, it is necessary to perform an analysis of specific activities for the other artificial radionuclides.

12-3

**Ultrasound procedures for improved protein extraction from pumpkin leaves Cucurbita pepo**

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Adequate protein intake is essential for the proper functioning of the human body. With Earth's overpopulation in mind, the quantity needed to be obtained is enormous. In order to reduce the load on the environment the main focus is on finding viable plant sources for protein extraction. Ribulose-1,5-bisphosphate carboxylase-oxygenase (RuBisCo) is the most widespread protein on Earth, distinguished by its interesting amino acid profile and promising functional properties. The main limitations of the extraction of bioactive compounds are small yields and long extraction times. To overcome these problems, numerous advanced techniques are used, one of which is ultrasound-assisted extraction. The main purpose of this paper was the examination of the impact that operating parameters have on the efficiency of protein extraction. The manipulated variables were: the pH of the extraction medium, solid/ liquid ratio, extraction time, and the amplitude (strength) of ultrasound waves. Measurement of the concentration of proteins is achieved by measuring the sample absorbance using Bradford's reagent. Within the preliminary segment of the experiments, both the pH of the extraction medium and the solid/ liquid ratio were optimized. The results indicated that the best yield is obtained by correcting the pH of the medium to 8, using the Tris-HCl buffer solution. When it came to the solid/ liquid ratio, 1:20 (w/v) gave the best results. Afterward, the ultrasound probe was introduced to the sample containing grounded-up leaves. By optimizing the extraction time and the ultrasound amplitude we were able to drastically reduce the extraction time while simultaneously increasing the yield. The results confirmed the effectiveness of ultrasound-assisted extraction as a method of separating bioactive compounds.

12-4

**Characterization of the historical glass samples**

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The aim of this work was to determine the appropriate methodology for the glass samples characterization. In the case of the limited number and amount of samples, the characterization methodology is necessary because of the performing order of the analyses and preserving samples as much possible by using non-destructive methods. The samples used in our investigations were glass tesserae in five different colours (white, green with a gold leaf between two layers of glass, yellow, red and purple) used for decoration of the façade of the City Hospital in Novi Sad (part of the Clinical Centre of Vojvodina). Based on the characterization of the tesserae, it was necessary to identify the glass composition, colouring agents and glass opacifying agents. For obtaining the glass composition, appropriate non-destructive quantitative and qualitative methods were used in the following order: VIS colourimetry, SEM-EDS, FTIR spectroscopy and Raman spectroscopy. Analysis of glass tesserae confirmed that the used methodology is appropriate for characterization of historical glass samples, and revelead production technology of the examined samples.

12-5

**Quality control of HPGe detectors for gamma spectrometry of environmental samples**

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Quality assurance and quality control (QA/QC) is a series of procedures aimed at verifying the validity of the measurement results and are defined in the Standard ISO 17025/17. QC should be planned, described in the quality control documentation, performed in a systematic manner, recorded and reviewed. All proposed measures for QC/QA are implemented in the Radiation and Environment Protection Department of Institute for Nuclear Sciences Vinča, Belgrade. One of these procedures prescribes a regular quality control of the instruments used for the measurement. In this paper, the quality control of three High Purity Germanium (HPGe) detectors, produced by Canberra, are presented. The accuracy and reproducibility of gamma spectrometry systems are verified on a weekly basis. Total background count rate is used to verify that the detector and shield has not been contaminated. Measurement of the total activity of calibration source is used to check the efficiency calibration and general operating parameters of the system such as peak shape and peak drift. These values are observed and verified if they are within the acceptance limits. For that purpose, $^{60}$Co and $^{133}$Ba point sources, produced by Czech Metrology Institute and traceable to Bureau International des Poids et Mesures (BIPM), are used. The acceptance limits for each controled parameter are defined according to the statistical analysis of the previous QC period. The acceptance limits are set to be ±2σ and ±3σ of the mean value taken over a previous year. Results of the QC measurement falling between ±2σ are considered to be satisfactory, the ones between ±2σ and ±3σ are warning and those exceeding ±3σ indicate that a problem with the measurement system has occurred. Analysing the QC data acquired for 2021, we can conclude that major part of parameters were within the limits of acceptance. Occasional discrepancies were minor and were addressed immediately. Discrepancies of the peak shape were corrected simply by additional cooling of the instrument, peak position by performing an energy calibration and background was corrected by ventilating the laboratory.

12-6

**Employing EFM as a nondestructive method for studying green corrosion inhibition of copper in chloride environment**

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Electrochemical frequency modulation (EFM) is useful nondestructive corrosion measurement technique. EFM can directly give values of the corrosion current without prior knowledge of Tafel constants. The determination of corrosion parameters is based on the response of the system to two sinusoidal waves that are applied simultaneously. The current response also contains the sum, difference and multiples of the two input frequencies. According to the literature related to the corrosion of copper in a chloride environment, the basic frequency was 1 Hz, while the two set frequencies were 2 Hz and 5 Hz. The experiments were derived in a three-electrode electrochemical cell at room temperature. The working electrode was made of copper, the reference electrode was a saturated calomel electrode and the counter electrode was made of platinum sheet. All experiments were performed using Gamry interface 1010e potentiostat/galvanostat/zra (Gamry Instruments). Processing of the results and extraction of intermodulation spectra was performed using Gamry Echem Analyst. Copper corrosion was investigated according to the wide usage of copper in industry and its tendency to corrode in a chloride environment. The corrosion behavior of copper in a chloride environment was investigated without and with the addition of the green inhibitor. The blackberry leaf extract was used as a green inhibitor. An ecological inhibitor was investigated in order to examine the possibility of using a cheap, non-toxic and sustainable agent that would replace the toxic inhibitors used until now. As result, the values of corrosion current density and Tafel slopes ($\beta_a$ and $\beta_c$) were attained. The corrosion rate and percentage of corrosion inhibition were calculated. The validity of the results was determined based on the values of causal factors. The results show that the application of EFM methods is very effective due to the ease of application and obtaining fast and reliable results. Also, the results show the possibility of using blackberry leaf extract as an inhibitor of copper corrosion in a chloride environment, whereby an increase in inhibition efficiency is achieved with an increase in inhibitor concentration.

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