SMS 2023
SMART MATERIALS AND SURFACES

NanoMed 2023

EGF 2023
European Graphene Forum

SENSORS 2023

SMS 2023 / NANOMED 2023 / EGF2023 / SENSORS 2023 JOINT CONFERENCES

25 - 27 October 2023
Albufeira, Portugal

Book of Abstracts

Organizer

SETCOR
Conferences & Exhibitions

SMS / NanoMed / Sensors / EGF 2023
Joint International Conferences Preliminary Program
25 - 27 October 2023, Albufeira/Algarve - Portugal

Wed. 25 Oct. 2023		
08:00 - 12:00	**Conference Registration - Grande Real foyer**	
SMS 2023 / EGF 2023 / Sensors 2023 / NanoMed 2023 Joint Plenary Session I		
Conference Room Sala Balaia		
Session Chairs: **Prof Tatiana Itina, Jean Monnet University, France** **Prof. Sandra Pulcinelli, UNESP, São Paulo State University, Brazil.** **Prof. Pankaj Vadgama, Queen Mary University of London, UK**		
10:30 - 11:00	The Mechanics of Deformation in Nanocomposites Reinforced with Graphene and other 2D Materials. **R. J. Young**	**Prof. Robert J Young**, University of Manchester, **UK**
11:00 - 11:30	Nano-surface science: chemical approaches to optical sensors **T. Trindade**	**Prof. Tito Trindade**, University of Aveiro, **Portugal**
11:30 - 11:45	Anthracene functionalized nanomaterials for selective and reversible self-assembly of fullerenes **P. Piotrowski**, A. Krogul-Sobczak and A. Kaim	**Dr. Piotr Piotrowski**, University of Warsaw, **Poland**
11:45 - 12:00	Effect of gadolinium in the structure of CeO2 **T. Petkova**, V.Boev, V.Ilcheva, G.Avdeev, N.Bozhanova, O.Kostadinova and V.Zhelev	**Prof. Tamara Petkova**, Institute of electrochemistry and energy systems, **Bulgaria**
12:00 - 14:00	**Lunch Break - Real Restaurant**	
SMS 2023 / Sensors 2023 / NanoMed 2023 Joint Session I. A: Materials synthesis, characterization and properties		
Session Chairs: **Prof. Tito Trindade, University of Aveiro, Portugal** **Prof. Christophe Caucheteur, University of Mons, Belgium**		
14:00 - 14:30	Smart Nanohybrids and Multi-material Nanoparticles: Synthesis, Properties, Modelling and Applications **T. E. Itina**	**Prof Tatiana Itina,** Jean Monnet University, **France**
14:30 - 14:45	Developing sandwich structure with novel biobased composite using additive manufacturing **M. Fazeli** and J. Lipponen	**Dr. Mahyar Fazeli,** Aalto University, **Finland**
14:45 - 15:00	Functional Block Copolymer Cubosomes with Broad Applicability. **M. Schumacher**, W. G. Zeier and A. H. Gröschel	**Mr. Marcel Schumacher**, University of Münster, **Germany**
15:00 - 15:15	3D Nanofabrication of Arbitrary Functional Materials. **X. Lyu**, M. Zhang, Z. Zheng, A. Shiva and M. Sitti	**Mr. Xianglong Lyu**, Max Planck Institute for Intelligent Systems, **Germany**
15:15 - 15:30	Investigation of parameters setup efficiency during abrasive waterjet turning of different materials. **A. Štefek** and L. M. Hlaváč	**Mr. Adam Stefek**,Technical University of Ostrava, **Czech Rep**
15:30 - 15:45	Reconfigurable micro-metastructures with wide-spectrum programmability actuated by hydrogel muscles. **M. Zhang** and M. Sitti	**Dr. Mingchao Zhang**, Max Planck Institute for Intelligent Systems, **Germany**
15:45 - 16:00	Investigation of Nonreciprocal Metasurfaces: Exploring Simple Structure and Smart Functions. **K. Takahagi** and A. Tennant	**Mr. Kazuhiro Takahagi**, The University of Sheffield, **UK**
16:00 - 16:30	**Afternoon Coffee Break - Grande Real Foyer**	
Session Chairs: **Dr. Petr Sittner, Czech Academy of Sciences, Czech Republic** **Prof Tatiana Itina, Jean Monnet University, France**		
16:30 - 17:00	Tilted fiber Bragg gratings (TFBGs): From multiparametric sensors to plasmonic biosensors. **C. Caucheteur**	**Prof. Christophe Caucheteur,** University of Mons, **Belgium**

17:00 - 17:15	Design and Additive Manufacturing of Newly Developed Mechanical Metamaterials for Structural Applications. **M. Fleisch,** A. Thalhamer 1, G. Pinter 2, S. Schlögl 1, M. Berer	**Mr. Mathias Fleisch**, Polymer Competence Center Leoben GmbH, **Austria**
17:15 - 17:30	Manufacturing of Soft Dielectric Actuator by multi-material Fused Filament Fabrication. **I. Ragu**, S. Schlögl, J. Brancart, B. Vanderborght, C. Holzer and M. Berer	**Mr. Ivan Raguž**, Polymer Competence Center Leoben GmbH, **Austria**
17:30 - 17:45	From unit cells to multifunctional components- 3D-printed metamaterials. **E. Truszkiewicz**, M. Fleisch, J. Lackner and M.Berer	**Ms. Eliza Truszkiewicz**, Polymer Competence Center Leoben GmbH, **Austria**
17:45 - 18:00	Production and Reforming of Glucose into High-Value Chemicals Using Nanostructured WO3 and WO3/TiO2 photoanodes. **K. Jakubow-Piotrowska**, B. Witkowski and J. Augustynski	**Dr. Katarzyna Jakubow-Piotrowska**, University of Warsaw, **Poland**
18:00 - 18:15	Development of electroanalytical devices for assessment of food safety and quality parameters in fish and shellfish. **R. Torre**, E. Costa-Rama, H.P.A. Nouws and C. Delerue-Matos	**Ms. Ricarda Torre,** REQUIMTE/LAQV- ISEP, **Portugal**

Wed. 25 Oct. 2023		
SMS 2023 / NanoMed 2023 - Session I. B: Smart coatings and Surfaces / Biomaterials		
Conference Room Sala Santa Eulália		
Session Chairs: **Prof. Redouane Borsali, Univ Grenoble Alpes, France** **Prof. Roland Fortunier, Ecole Centrale Lyon, France** **Prof K Jimmy Hsia, Nanyang Technological University, Singapore**		
14:00 - 14:30	Effect of cold plasma process parameters for organosilicon deposition on corrosion protection performance. **C. Jama**	**Prof. Charafeddine Jama,** Centrale Lille Institute, **France**
14:30 - 14:45	Plasma Electro Oxidation technology as a clean and efficient alternative for the development of advanced coatings on light alloys. **R. Bayón**, P. Fernández-López, S. Alves and E. Gutiérrez-Berasategui	**Dr. Francesco Pagano**, TEKNIKER. Basque Research and Technology Alliance, **Spain**
14:45 - 15:00	Novel PEO coatings developed on a secondary cast Al-Si alloy under pulsed bipolar polarisation for brake applications. **P. Fernández-López**, A. Rogov, S. Alves, R. Bayón, I; Quintana and A. Yerokhin	**Dr. Patricia Fernández López**, TEKNIKER. Basque Research and Technology Alliance, **Spain**
15:00 - 15:15	Multi-scale Simulation of Oxidation Effects on Wetting Properties of Fentosecond Laser-treated Surface. **I. S. Omeje** and T.E. Itina	**Mr. Ilemona S. Omeje**, Jean Monnet University, **France**
15:15 - 15:30	Laser-based production of anti-stick coatings on CFRP rolls. **M. Dahmen**, C. Hensch and S. Fink	**Mr. Marius Dahmen**, Fraunhofer Institute for Laser Technology ILT, **Germany**
15:30 - 15:45	Innovative Solar Thermal Collector Coatings for Improved Mechanical Properties and Energy Efficiency. **I. Pana**, A. C. Parau, M. Dinu, L. R. Constantin, A. E. Kiss, A. Vladescu (Dragomir) and C. Vitelaru	**Dr. Iulian Pana**, Nat. Institute of Research and Dev. for Optoelectronics - INOE2000, **Romania**
15:45 - 16:00	Anti-microbial surfaces for use in aircraft cabins. **S. Geier**, S. Koch, F. Kühnast, P. Wierach and R. Möller	**Dr. Sebastian Geier**, German Aerospace Center (DLR), **Germany**
16:00 - 16:30	**Afternoon Coffee Break - Grande Real Foyer**	
Session Chairs: **Prof. Charafeddine Jama, Centrale Lille Institute, France** **Prof K Jimmy Hsia, Nanyang Technological University, Singapore**		
16:30 - 17:00	Self-assembly of carbohydrate block copolymers: from glyconanoparticles to thin films. **R. Borsali**	**Prof. Redouane Borsali**, Univ Grenoble Alpes, **France**
17:00 - 17:15	Transparent Silver-based Coatings Embedded in Oxide Matrices used for Antibacterial Applications. **C. Vitelaru**, A.C. Parau, A. E. Kiss, I. Pana, M. Dinu, L. R. Constantin, A. Vladescu(Dragomir), L. E. Tonofrei, C.S. Adochite, S. Costinas, L. Rogozea, M. Moga, M. E. Idomir and M. Badea	**Dr. Catalin Vitelaru,** National Institute for Research and Development in Optoelectronics - INOE 2000, **Romania**
17:15 - 17:30	Novel coatings for alumina nanoporous membranes: investigation of in vitro antifouling properties. **M. Moaness**, S.A.M. El-Sayed, H. H. Beherei and M. Mabrouk	**Dr. Mostafa Mabrouk**, National Research Centre-Cairo, **Egypt**
17:30 - 17:45	Electrospun Nanofibers Activated by Amoxicillin Loaded Mesoporous Titania for Bone Regeneration. **M. Moaness**, M. Mabrouk, B. E. Abdel-Ghany, Z. A. Salem B. M. Abdel-Hady and H. H. Beherei	**Dr. Mona Moaness,** National Research Centre, Cairo, **Egypt**
17:45 - 18:00	Comparative Neuroprotective Potential of Nanoformulated and Free Resveratrol against Cuprizone-enhanced Neuroinflammation. **S. A. M. El-Sayed**, G. Ibrahim Fouad, M.Z. Rizk, D. B. Fayed, H.H. Beherei and M. Mabrouk	**Dr. Sara A. M. El-Sayed**, National Research Centre-Cairo, **Egypt**
18:00 - 18:15	Creating and exploring non-reciprocal colloidal microparticles as swimmers **E. Coimbra**, S. Sacanna, N. J. O Silva and F.L. Sousa1	**Mr. Eduardo Coimbra**, University of Aveiro, **Portugal**

Wed. 25 Oct. 2023		
EGF 2023 - Session I. C: Graphene and 2D Materials synthesis, characterization, and properties		
Conference Room Sala Algarve		
Session Chairs: Prof. Robert J Young, University of Manchester, UK Dr. Artur M. Pinto, LEPABE- University of Porto, Portugal		
14:00 - 14:30	Bringing atomic precision to the synthesis of graphene-based lateral heterostructures. **A. Mugarza**	**Prof. Aitor Mugarza,** Catalan Institute of Nanoscience and Nanotechnology (ICN2), **Spain**
14:30 - 15:00	Molecular Modelling of Structure and Mobility of Aqueous Electrolytes in Neutral and Charged Graphene Nanochannels. **M. Lísal**	**Prof. Martin Lisal**, Institute of Chemical Process Fundamentals- Prague, **Czech Rep.**
15:00 - 15:15	Lateral Growth of Tungsten Disulfide-Graphene Heterostructures us-ing Chemical Vapour Deposition for Large Scale 2D Devices Fabrication. **S. Alodan**, H. Bai, H. Almousa, A. Bin Muhammad Mustafa, S. Ramadan and, N. Klein	**Ms. Sarah Alodan**, Imperial College London, **UK**
15:15 - 15:30	Growth of III-V Semiconductors on Graphene. **N. Nateghi** and O. Moutanabbir	**Dr. Nima Nateghi**, TAV College- Montreal, **Canada**
15:30 - 15:45	Van der Waals Semiconductors: Exploring the Potential of Oxidation-Induced Heterostructures. **G. D'Olimpio**, A. Politano and D. Bukhvalov	**Dr. Gianluca D'Olimpio**, University of L'Aquila, **Italy**
15:45 - 16:00	Thermal probe of correlated states in bilayer graphene. **F. Ghahari**	**Prof. Fereshte Ghahari,** George Mason University, **USA**
16:00 - 16:30	**Afternoon Coffee Break - Grande Real Foyer**	
Session Chairs: Prof. Robert J Young, University of Manchester, UK Dr. Artur M. Pinto, LEPABE- University of Porto, Portugal		
16:30 - 17:00	Colorimetric, Quantitative Chemical Detection by MOF-Based Test Strips: From Fundamental Studies to Corporate Development of a Novel Field-Deployable Sensing Platform. **S. M. Humphrey**	**Prof. Simon M. Humphrey**, The University of Texas at Austin, **USA**
17:00 - 17:15	Graphene functionalization via electrochemical Pd nanoparticles deposition to enhance ammonia sensing. **S. Freddi**, M. C. R. Gonzalez, H. H. Creus and L. Sangaletti	**Dr. Sonia Freddi**, Cattolica del Sacro Cuore University, **Italy**
17:15 - 17:30	Molecularly imprinted sensors for electrochemical analysis of pharmaceuticals in environmental waters. **P. Rebelo**, J. G. Pacheco, I. V. Voroshylova, I. Seguro, A. Melo, M. N. D. S. Cordeiro and C. Delerue-Matos	**Ms. Patrícia Rebelo**, REQUIMTE/ LAQV/ GRAQ Porto, **Portugal**
17:30 - 17:45	Advancing Chemical Sensors through Novel Architectures Based on Functional Hybrid Nanofibers. **D.S. Correa**	**Dr. Daniel S. Correa**, Embrapa Instrumentação, **Brazil**
17:45 - 18:00	Terahertz Array Beamforming Using Low-Voltage Graphene-Modulators. **R. Silva** and P. M. Mendes	**Mr. Rui Silva**, University of Minho, **Portugal**

Thu. 26 October 2023		
EGF 2023 / SMS 2023 Session II. A: Graphene properties and applications Functional / Multifunctional, Hybrid, Composites and Responsive Materials		
Conference Room Sala Balaia		
Session Chairs: Prof. Robert J Young, University of Manchester, UK Prof. K Jimmy Hsia, Nanyang Technological University, Singapore Prof. Aitor Mugarza, Catalan Institute of Nanoscience and Nanotechnology (ICN2), Spain		
09:00 - 09:30	Understanding thermal transport in Transition Metal Dichalcogenides: from the monolayer to the bulk. **P. Ordejon**	**Prof. Pablo Ordejon**, Catalan Institute of Nanoscience and Nanotechnology (ICN2), **Spain**
09:30 - 10:00	Large-scale production and commercialization of graphene-based solutions for electromagnetic interference shielding applications. **J. Rodrigues**	**Mr. João Rodrigues,** Graphenest - Advanced Nanotechnology, **Portugal**
10:00 - 10:30	Plastic deformation of B19' martensite in NiTi shape memory alloy. **P. Sittner,** O. Molnarova, X. Bian, O. Tyc, L. Heller, P. Sedlak and H. Seiner	**Dr. Petr Sittner**, Czech Academy of Sciences, **Czech Republic**
10:30 - 11:00	**Morning Coffee Break - Grande Real Foyer**	
Session Chairs: Prof. Robert J Young, University of Manchester, UK Dr. Petr Sittner, Czech Academy of Sciences, Czech Republic Prof. Aitor Mugarza, Catalan Institute of Nanoscience and Nanotechnology (ICN2), Spain		
11:00 - 11:30	Overcoming the adhesion paradox and switchability conflict on rough surfaces with shape memory polymers. C. Linghu, H. Gao and **K Jimmy Hsia**	**Prof. K Jimmy Hsia**, Nanyang Technological University, **Singapore**
11:30 - 11:45	Mechanics of Shape-Locking-Governed R2G Adhesion with Shape Memory Polymers. **C. Linghu**, H. Gao and K. J. Hsia	**Mr. Changhong Linghu**, Nanyang Technological University, **Singapore**
11:45 - 12:00	Thermal response of double network hydrogels. **L. Hanyková**, I. Krakovský, J. Šťastná and J. Labuta	**Dr. Lenka Hanyková**, Charles University, **Czech Rep.**
12:00 - 12:15	Influence of the addition of antimicrobial low molecular weight chitosan on the thermal and rheological properties of polybutadiene succinate composites. **R. Merijs-Meri**, J. Zicans, T. Ivanova, M. Žiganova, R. Berzina and J. Bitenieks	**Prof. Remo Merijs-Meri**, Riga Technical University, **Latvia**
12:15 – 12:30	Ceria-Based Nanocomposites for Catalysis by Magnetic Heating. **D. Makovec**, N. Križaj Kosi Ž. Trošt, J. Tržan, M. Grilc and S. Gyergyek	**Prof. Darko Makovec**, Jožef Stefan Institute, **Slovenia**
12:00 - 14:00	**Lunch Break – Real Restaurant**	
Group Photo at 13:45		
Smart Materials and Surfaces / Sensors 2023 Session II. B: New Materials for sensors and actuators: Sensing the Future with New Materials		
Session Chairs: Prof. Riccarda Antiochia, University of Rome "La Sapienza", Italy Prof. Maria Vittoria Diamanti, Politecnico di Milano, Italy		
14:00 - 14:30	Tactile Perception of Virtual Surfaces generated by Piezoelectric Actuators. C. Bertheaux, I. A. Ivan, D. Ruiz-Lopez, L. Quiblier, J. C. Roux and **R. Fortunier**	**Prof. Roland Fortunier**, Ecole Centrale Lyon, **France**
14:30 - 14:45	Metallic nanoparticles-based nanomaterial as a non-enzymatic sensor. **M. Kuznowicz**, A. Jędrzak, T. Rębiś and T. Jesionowski	**Ms. Maria Kuznowicz**, Poznan University of Technology, **Poland**
14:45 - 15:00	Novel Gas Phase Route Towards Patterned Deposition of Pt/Al reactive multilayers. **N. A. Isaac**, L. Schlag, J. Reiprich, A. Islam, A. K. Soydan, J. Pezoldt and H. O. Jacobs	**Mr. Nishchay Angel Isaac**, TU Ilmenau, **Germany**

15:00 - 15:15	Transparent thin films for use as position sensitive photodetector. **P. Petkov**, V. Zhelev, P.Bancheva-Koleva and T. Petkova	**Prof. Plamen Petkov**, University of Chemical Technology and Metallurgy-Sofia, **Bulgaria**
15:15 - 15:30	Layer by layer method used to investigate correlation between rigidity of matrix and sensitivity of sensors device. **T. Chudziak**, P. Samorì and A. Ciesielski	**Mr. Tomasz Chudziak**, University of Adam Mickiewicz, **Poland**
15:30 - 15:45	Gas sensitivity analysis of the gas-triggered resistive switch – gasistor. **M. Patrnčiak**, M.Vidiš, M Moško, A. Plecenik, L. Satrapinskyy, T. Roch, P. Ďurina and T. Plecenik	**Mr. Michal Patrnčiak**, Comenius University Bratislava, **Slovakia**
15:45 - 16:00	Development of optical microsensors based on Surface Plasmon Resonance for gas measurement in atmosphere. **J. Brunet**, H. Bruhier, T. Gueye, S. Rajab Pacha, P. Giraud, A. Ndiaye, C. Varenne, A. Pauly, I. Verrier and Y. Jourlin	**Dr. Jerome Brunet**, University of Clermont Auvergne, **France**
16:00 - 16:30	**Afternoon Coffee Break - Grande Real Foyer**	
SMS / NanoMed / Sensors 2023 Joint Session II. C: Biosensors and sensors for medical applications		
Session Chairs: Prof. Roland Fortunier, Ecole Centrale Lyon, France Prof. Plamen Petkov, University of Chemical Technology and Metallurgy- Sofia, Bulgaria Prof. Pankaj Vadgama, Queen Mary University of London, UK		
16:30 - 17:00	A disposable immunosensor for detection of salivary MMP-8 as biomarker of periodontitis. **R. Antiochia**	**Prof. Riccarda Antiochia**, University of Rome "La Sapienza", **Italy**
17:00 - 17:15	β-cyclodextrins grafted on magnetite@polynorepinephrine as a potential long-term mobile glucose biosensor. **A. Jędrzak**, M. Kuznowicz and T. Jesionowski	**Mr. Artur Jędrzak**, Poznan University of Technology, **Poland**
17:15 - 17:30	Assessing SAR Levels in Microwave Sensors for Breast Cancer Detection: Ensuring Patient Safety. **A. Rangel-Trejo**, A. Quiceno-Villa and L. Fakri-Bouchet	**Mr. Abel Rangel Trejo**, University of Claude Bernard Lyon 1, **France**
17:30 - 17:45	In-Situ Investigation of Cellular Level Biomarkers Using Atomic Force Microscopy (AFM) Based Nano Robot. Y. Xue, Y. Wang, X. Liu and **N. Xi**	**Dr. Ning Xi**, The University of Hong Kong- Hong Kong, **China**
17:45 - 18:00	Pioneering Disease Diagnosis Platform: Leveraging Differential Dynamic Microscopy. **S. Salimi**, P-L. Latreille, M. Le Goas, D-C. Boffito, J. Arlt, V. Martinez and X. Banquy	**Mr. Sina Salimi**, University of Montréal, **Canada**
18:00 - 18:15	Controlled Design of Aptasensing Platforms for Food Contaminants Detection through Aryl Diazonium Electrochemistry. A. M. Onaş, C.V. Florea, A.M. Pandele, M. Raicopol and **L. Pilan**	**Dr. Luisa Pilan**, University Politehnica of Bucharest, **Romania**
18:15 - 18:30	Detection of highly diluted single-nucleotide polymorphism in healthy DNA using graphene field-effect transistors **T. Domingues**, J. Borme, B. Costa, M. Martins and P. Alpuim	**Mrs. Telma Domingues**, International Iberian Nanotechnology Laboratory, **Portugal**

Conference Dinner
Conference venue hotel
26 Oct. 2026 from 19:30

Thu. 26 October 2023		
NanoMed / Sensors joint Session II. A: Bioinspired, Biomimetic bioactive biomaterials Intelligent drug delivery and release system		
Conference Room Sala Santa Eulália		
Session Chairs: Prof. Redouane Borsali, Univ Grenoble Alpes, France Prof. Antonio Gloria, University of Naples Federico II, Italy		
09:00 - 09:30	Nanotechnology-based assessment of Flavivirus assembly and its inhibition. **N.C. Santos**	**Prof. Nuno C. Santos,** iMM Lisboa, **Portugal**
09:30 - 10:00	Nanocrystals as novel nanomedicines in cancer. **N. Mignet**, B. Martin, P. Ma, H. Dhotel, B. Saubamea, J. Seguin and Y. Corvis	**Prof. Nathalie Mignet**, University Paris Cité, UTCBS, CNRS, INSERM, **France**
10:00 - 10:15	Hybrid PEM/wax coatings for surface biofunctionalization. **T. Andreeva** and R. Krastev	**Dr. Tonya Andreeva**, Reutlingen University**, Germany**
10:30 - 11:00	**Morning Coffee Break - Grande Real Foyer**	
11:00 - 11:30	Next-Generation Ultrasensitive Sensors Using Antibody-Mimetic Protein Scaffolds. **L. Movileanu**	**Prof. Liviu Movileanu**, Syracuse University, **USA**
11:30 - 11:45	Fast emitting scintillating nanocomposites for high resolution ToF-PET imaging. M. Orfano, M. Rurali, A. Monguzzi and **I. Villa**	**Dr. Irene Villa**, University of Milano-Bicocca, **Italy**
11:45 - 12:00	Multifunctional Nanotubes for X-ray activated photodynamic therapy (X-PDT). **V. Secchi**, I. Villa, C. Villa, Y. Torrente, A. Vedda and A. Monguzzi	**Dr. Valeria Secchi**, University of Milano-Bicocca, **Italy**
12:00 - 14:00	**Lunch Break – Real Restaurant**	
Group Photo at 13:45		
SMS / NanoMed / Sensors 2023 joint Session II. B: Biomaterials / NanoBioMaterials / Bioimaging / Biosensors		
Session Chairs: Prof. Liviu Movileanu, Syracuse University, USA Prof. Charafeddine Jama, Centrale Lille Institute, France		
14:00 - 14:30	New pharmaceutical formulations containing two-dimensional nanomaterials for phototherapy. **A.M. Pinto**	**Dr. Artur M. Pinto**, LEPABE- University of Porto, **Portugal**
14:30 - 14:45	Synthesis of stable colloidal suspensions of non-superparamagnetic nanoparticles for magneto-rheology bio applications. **J. M. Costa**, G. F. Resende, Y. Gu, J. N. M. Silvares, M. R. Lagarto, F. L. Sousa,V. M. Gaspar, J. F. Mano, A. Millán, J.-L. Garcia-Palacios, A. Namai, M. Yoshikiyo, S. Ohkoshi and N. J. O. Silva	**Mr. João Costa**, University of Aveiro, **Portugal**
14:45 - 15:00	Natural Receptors for Electrochemical Biosensors Assembly: The Case of IL-5Rα. **D. J. Pérez**, E. B. Patiño and J. Orozco	**Mr. David J. Pérez Cardona**, University of Antioquia, **Colombia**
15:00 - 15:15	Graphene Oxide: an efficacious Challenge for the Chronic Wounds management. **S. Di Lodovico**, F. Diban, P. Di Fermo, S. D'Arcangelo, S. D'Ercole, L. Cellini and M. Di Giulio	**Dr. Silvia Di Lodovico**, University "G. d'Annunzio" Chieti-Pescara, **Italy**.
15:15 - 15:30	Effect of biocompatibility in alginate 3D Scaffolds using calcium pyrophosphates (β-CPP) ceramics. G. C. Pinto, R. D. Piazza, I. P. M. Soares, A. F. Cunha, C. Anselmi, M. B. Oliveira, C. A. S. Costa, A. C. Guastaldi, N. J. O. e Silva	**Dr. Gabriel C. Pinto**, University of Aveiro, **Portugal**
16:00 - 16:30	**Afternoon Coffee Break - Grande Real Foyer**	

Session Chairs: Prof. Liviu Movileanu, Syracuse University, USA Prof. Charafeddine Jama, Centrale Lille Institute, France		
16:30 - 17:00	Bioinspired Design for Additive Manufacturing Towards the Development of Innovative Devices for Biomedical and Industrial Applications. **A. Gloria**, I. Papallo, M. Domingos, N. Alves and M. Martorelli	**Prof. Antonio Gloria**, University of Naples Federico II, **Italy**
17:00 - 17:15	Elimination of pathogenic E. coli bacteria using bioinspired plasmonic optical metasurfaces. A; Smith, M. Mazloumi, L; Karperien, C; Escobedo and **R.G. Sabat**	**Prof. Ribal Georges Sabat**, Royal Military College of Canada, **Canada**
17:15 - 17:30	Interaction of Microparticles of Different Rigidities with Serum and Plasma Proteins. **E. Gerasimovich**, G. Nifontova, I. Nabiev and A. Sukhanova	**Ms. Evgeniia Gerasimovich**, Life Improvement by Future Technologies Center, **Russia**

Conference Dinner
Conference venue hotel
26 Oct. 2023 from 19:30

Thu 26 Oct. 2023		
NanoMed 2023 Session II. C: Nanomaterials for Biomedical / Tissue engineering, drug, and gene delivery		
Conference Room Sala Algarve		
Session Chairs: Prof. Nuno C. Santos, iMM Lisboa, Portugal Prof. Nathalie Mignet, University Paris Cité, France		
14:00 - 14:30	Chameleon Nanocarriers for Delivery of Therapeutic RNA. **E. Wagner**	**Prof. Ernst Wagner**, Ludwig-Maximilians-University (LMU) München, **Germany**
14:30 – 14:45	Self-assembly of Cyanidin 3-O-glucoside and negative charged polysaccharides. A structural study. **P. Di Gianvincenzo**, N. Chotechuang, D. Padro, M. G. Ortore and S. E. Moya	**Dr. Paolo Di Gianvincenzo,** CIC biomaGUNE**, Spain**
14:45 - 15:00	Development of Stable and Biocompatible Super-paramagnetic Iron Oxide Nanoparticles (SPIONs) and Study of their Spatial Structuration upon the Application of an External Magnetic Field (MF). **J. Mistral**, P. Nunes De Oliveira, G. Sudre, A. Serghei, O. Chapet, C. Ladavière and L. David	**Mr. Jules Mistral**, Université Claude Bernard Lyon, **France**
15:00 - 15:15	nanoTARG: a nanotechnological platform for the management of ZIP4-positive tumours. **P. Perez Schmidt** and P. Rivera Gil	**Dr. Patricia Perez Schmidt**, Pompeu Fabra University, **Spain**
15:15 - 15;30	Designing an optical nanosensor to non-invasively monitor tumor metastasis. **T. Zhou** and P. Rivera Gil	**Ms. Ting Zhou**, Pompeu Fabra University, **Spain**
15:30 - 15:45	Nanovesicles tested on human skin explants preserved in an innovative fluid dynamic system. **A. Galvan**, M. Malatesta, E. Esposito and L. Calderan	**Dr. Andrea Galvan**, University of Verona, **Italy**
15:45 - 16:00	Polymer carrier of cytotoxic drugs with P-gp-overcoming capacity in the treatment of chemoresistant tumors. **M. Sirova**, M. Kana, A. Braunova, M. Frejkova, T. Etrych, B. Rihova and M. Kovar	**Dr. Milada Sirova**, Institute of Microbiology of the Czech Academy of Sciences, **Czech Rep.**
16:00 - 16:30	**Afternoon Coffee Break - Grande Real Foyer**	
Session Chairs: Prof. Nuno C. Santos, iMM Lisboa, Portugal Prof. Nathalie Mignet, University Paris Cité, France Dr. Irene Villa, University of Milano-Bicocca, Italy		
16:30 - 16:45	HPMA copolymer conjugates bearing novel STAT3 inhibitor and doxorubicin covalently linked through pH-sensitive bond possess in combination significant antitumor activity in vivo. **M. Kovar**, V. Subr, K. Behalova, M. Studenovsky, D. Starenko, J. Kovarova, T. Etrych and L. Kostka	**Dr. Marek Kovar**, Institute of Microbiology of the Czech Academy of Sciences, **Czech Rep**.
16:45 - 17:00	Synthesis of cRGD functionalized nanosystems for tumor site-specific delivery of anticancer agents. G. Bisbano, D. Rubes, M. Zupi, E. Bari, M. Paolillo, F. Doria, M. Filice, M. Terreni and **M. Serra**	**Dr. Massimo Serra**, University of Pavia, **Italy**
17:00 - 17:15	Design and optimization of nano-formulations for a novel colchicine derivative. **M. Rubicondo**, C.Mattu and J. A. Tuszynki	**Mrs. Marialucia Rubicondo,** Polytechnic Torino, **Italy**
17:15 - 17:30	Engineering Efficient Car-T Cells via Electroactive Nanoinjection. A-R Shokouhi, Y. Chen, H. Zhe Yoh, J. Brenker, T. Alan, T. Murayama, K. Suu, Y. Morikawa, N.H. Voelcker and **R. Elnathan**	**Dr. Roey Elnathan**, Deakin University, **Australia**
17:30 - 17:45	Platinum nanoparticles synthesized with lumichrome for UV-light cancer therapy. **R. Rey-Méndez,** N. González-Ballesteros, M. C. Rodríguez-Argüelles, S. Pinelli, P. Mozzoni, F. Rossi, F. Fabbri and F. Bigi	**Ms. Raquel Rey-Mendez**, University of Vigo, **Spain**
17:45 -18:00	Efficient and Rapid Production of Bio-inspired Nanoparticles Derived from Bombyx mori Silkworm for Enhanced Breast Cancer Treatment. **M. Muhamad Hawari** and M. Munitta	**Mr. Muhamad Hawari Mansor**, University of Sheffield, **UK**

18:00 - 18:15	Microfluidic-mediated ZIF-Silk-Polydopamine Core-Shell Nanoparti-cles for Delivery of Zinc Ions and Curcumin in Breast Cancer Therapy. **Z. Gao**, M. Hawari Mansor, N. Winder, S. Demiral, J. Maclnnes, X. Zhao and M. Muthana	**Mr Zijian Gao,** University of Sheffield, **UK**

Conference Dinner
Conference venue hotel
26 Oct. 2026 from 19:30

Fri. 27 Oct. 2023		
SMS / EGF 2022 Session III.A: Applications for energy and environment		
Conference room Sala Santa Eulália		
Session Chairs: Prof. Sandra Pulcinelli, UNESP, São Paulo State University, Brazil. Prof. Joseph Kirui, University of Venda, South Africa		
09:00 - 09:30	Environmental Applications of Anodic TiO2 Films for Water and Air Purification. **M.V. Diamanti**, U. Bellè and M.P Pedeferri	**Prof. Maria Vittoria Diamanti**, Politecnico di Milano, **Italy**
09:30 - 09:45	Grafysorber® Technology Innovative solution of oil recovery by emulsion treatment. **M. Vlaicu**, M. V. Nae, B. Schlager, R. Popescu,V. Giugliano and V.Dragoman	**Mrs. Mihaela Vlaicu**, OMV Petrom, **Romania**
09:45 - 10:00	Thermal analysis of magnesium hydride. **R. Skvorčinskienė**, L. Vorotinskienė, N. Striūgas, M. Urbonavičius and K. Zakarauskas	**Dr. Raminta Skvorčinskienė,** Lithuanian energy institute, **Lithuania**
10:00 - 10:30	**Morning Coffee Break - Grande Real Foyer**	
10:30 - 10:45	Elucidating the Trajectory of the Charge Transfer Mechanism and Recombination Process of Hybrid Perovskite Solar Cells. **J. K. Kirui**, S. A. Olaleru, L. Jhamba, D. Wamwangi, K. Roro, A. Shnier, R. Erasmus and B. Mwakikunga	**Prof. Joseph Kirui**, University of Venda, **South Africa**
10:45 - 11:00	A Novel MgFe2O4/Bi4O5Br2 Heterojunction Photocatalyst with Enhanced Photocatalytic Activity for Degradation of Bisphenol A and Reduction of Cr(VI) under Visible light. **T. Luangwanta**, R. Prathumpitak, T. Yungyongsakul and S. Kaowphong	**Mr. Tawanwit Luangwanta**, Chiang Mai University, **Thailand**
12:00 - 14:00	**Lunch Break- Real Restaurant**	

Trip to Algarve Area (Lagos / Cape St. Vincent / Sagres)
Conference venue hotel
27 October 2023 from 13:30 – 19:00
Complementary – Limited Seats

Fri. 27 Oct. 2023		
NanoMed / Sensors 2023 Session III.B		
Conference room Sala Algarve		
Session Chairs: **Prof. Simon M. Humphrey, The University of Texas at Austin, USA** **Prof. Liviu Movileanu, Syracuse University, USA**		
09:30 - 09:45	DNA Conformational Changes Induced by Its Interaction with Platinum Complexes in Solution. Comparison of Platinum, Ruthenium and Cadmium compounds. **N. Kasyanenko**, V. Bakulev and V. Demidov	**Prof. Nina Kasyanenko**, Saint Petersburg State University, **Russia**
09:45 - 10:00	Printed Sensors, Biosensors and Actuators: Current and future trends for Point-of-Need applications. **A. Ben Aissa** and A. Moya	**Dr. Alejandra Ben-Aissa Soler**, Eurecat, **Spain**
10:00 - 10:30	**Morning Coffee Break - Grande Real Foyer**	
10:30 - 11:00	Industrial Measurements, Communications and Protocols. **J. D. Pereira**	**Prof. José Dias Pereira,** Telecommunication Institute Lisboa, **Portugal**
11:00 - 11:15	Electrochemical Impedance Spectroscopy as a tool for discovering antimicrobial agents from environmental sources. **E. Rosqvist**, P. San-Martin-Galindo, J.Y. Kauhaluoma and J. Peltonen	**Dr. Emil Rosqvist**, Åbo Akademi University, **Finland**
11:15 - 11:30	Synergistic Influence of Static Magnetic Field and Magnetite-nanoparticles on a Microbial Fuel Cell in Anaerobic Digestion. **N.I. Madondo**, S. Rathilal, B.F. Bakare and E.K. Tetteh	**Dr. Nhlanganiso I. Madondo,** Durban University of Technology, **South Africa**
11:30 - 11:45	A Laser Modulation-based Fiber-Optic Fabry-Perot Interferometer for High Precision Pulse Wave Monitoring. **P. Samartkit**, S. Pullteap, H. C. Seat and M. Cattoen	**Mr. Piyawat Samartkit**, Silpakorn University, **Thailand**
12:00 - 14:00	**Lunch Break – Real Restaurant**	

Trip to Algarve Area (Lagos / Cape St. Vincent / Sagres)
Conference venue hotel
13:30 – 19:00
Complementary – Limited Seats

N.B:

For the Oral Presentation:

Duration of each talk type (including 2 to 3 minutes for Questions/Answers):

- We do not impose a template for the oral presentations,
- Oral presentation: 15 minutes,
- Keynote talk: 30 minutes.

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- Poster dimensions must be **100cm high X 80cm wide** maximum.
- We do not impose a template for the poster content.

SMS / Sensors/ NanoMed / EGF 2023 Joint International Conferences

Posters Session (Grande Real foyer)

All Posters are to be displayed for 25 and 26 Oct. 2023 - Grande Real Foyer

N.	Poster Title	Author, Affiliation, Country
1.	Laser-Induced Graphene on Sodium Alginate. **T. Vićentić**, I. Greco, D. Bajuk-Bogdanović, K. Radulović, I. Pašti, C. S. Iorio and M. Spasenović	**Ms. Teodora Vicentic**, Institute of Chemistry, Technology and Metallurgy, **Serbia**
2.	Wettability characteristics of Al-6061 alloy surface generated using high frequency Longitudinal Vibration assisted end-milling. T. Jo Ko, S. Ali, R. Kurniawan and M. Xu	**Prof. Tae Jo Ko**, Yeungnam University, **Rep. of Korea**
3.	Multifunctional Microstructured Surfaces using Microcontact Printing of Microgels. **I.E. Litzen**, A. Töpel, A. Sechi and A. Pich	**Ms. Inga Litzen**, RWTH Aachen University, **Germany**
4.	Optical and mechanical properties assessment for the main sol-gel ZrO2 coatings in CSP plants. M. Botejara-Antúnez, **A. Díaz-Parralejo**, A. Macías-García, D. Maya-Retamar and J. García-Sanz-Calcedo	**Dr. Antonio Díaz Parralejo**, University of Extremadura, **Spain**
5.	CrSi-based carbo-nitrides protective coatings for industrial wood-working applications. **L.R. Constantin**, A.C. Parau, M. Dinu, I. Pana, C. Vitelaru and Alina Vladescu (Dragomir)	**Dr. Lidia Ruxandra Constantin**, National Institute of Research and Development for Optoelectronics - INOE 2000, **Romania**
6.	Contribution of Nanoparticles of Mixed Oxides Derived from LDH in the Crystallization of Cement Phases During Hydration. A.A. Almeida, C.C. Dos Santos, V. Briois, S.H. Pulcinelli and **C.V. Santilli**	**Prof. Celso Santilli**, UNESP, São Paulo State University, **Brazil**
7.	The Relevance of Iron Distribution in Smectite Clays on the Improvement of the Thermostability of PMMA-Clay Nanocomposites. C.R. Ferreira, C.V. Santilli, V. Briois and **S.H. Pulcinelli**	**Prof. Sandra Pulcinelli**, UNESP, São Paulo State University, **Brazil.**
8.	On the mechanical and rheological properties of polybutadiene succinate based nanocomposites with nanoclay. **J. Zicans,** R. Merijs-Meri, T. Ivanova, I. Bockovs and J. Bitenieks	**Dr. Janis Zicans**, Riga Technical University, **Latvia**
9.	Real-time observation of molecular stacking using Low-Energy Electron Microscopy. **P. Procházka** and J. Čechal	**Dr. Pavel Procházka**, Brno University of Technology, **Czech Rep.**
10.	Investigation of atomically thin 2D indium intercalated under epitaxial graphene on SiC using scanning tunneling microscopy. **V. D. Pham**, C. Dong and J. A. Robinson	**Dr. Van Dong Pham**, Paul Drude Institute- Berlin, **Germany**
11.	Electrochemical Sensor for Benserazide: Molecularly Imprinted Polymer on a Paper-based Platform. **I. Seguro**, J. G. Pacheco and C. Delerue-Matos	**Mrs. Isabel Seguro**, REQUIMTE/ LAQV - Porto, **Portugal**
12.	Molecularly imprinted polymer-based electrochemical sensor for simple and fast analysis of tetrodotoxin. **P. Rocha**, P. Rebelo, J.G. Pacheco, D. Geraldo, F. Bento, J.M. Leão, C. Delerue-Matos and H.P.A. Nouws	**Mr. José Pedro Rocha,** REQUIMTE/ LAQV - Porto, **Portugal**
13.	An electronic nose based on CNTs functionalized with zinc phthalo-cyanine for wine aging detection. **S. Freddi** and L. Sangaletti	**Dr. Sonia Freddi**, Cattolica del Sacro Cuore University, **Italy**
14.	Impedimetric FIA enzyme inhibition-based biosensor system for determination of heavy metal ions in water. **V. M. Pyeshkova**, V.A. Bakhmat, O. O. Soldatkin, S. Krishnamurthy and S. V. Dzyadevych	**Dr. Viktoriya Pyeshkova,** The open University, **UK**
15.	Development of biosensors for phenol compounds utilizing Langmuir and Langmuir-Blodgett nano-organized films containing laccase. **A.C. Machado**. and L. Caseli	**Mr. André Campos Machado,** Federal University de São Paulo, **Brazil**
16.	Flexible copper nanowire-based electrodes: Optical and mechanical properties for soft electronics. NW Hoy, LS Mpeta and **PS Mbule**	**Prof. Pontsho Mbule**, University of South Africa-Johannesburg, **South Africa**

17.	Degradation Analysis of Organic Solar Cells. **D. Valiente**, F. Rodríguez-Mas, A. Hortal, A. Ruiz, J. C. Ferrer, J. L. Alonso, P. Corral and S. Fernández de Ávila	**Dr. David Valiente Garcia**, Miguel Hernández University, **Spain**
18.	Improvements on Carbon Based Porous Silicon Supercapacitor Through Electrochemical Deposition of Cobalt Hexacyanoferrate Nanocubes. **I-N. Bratosin**, M.C. Stoian, G. Craciun, N. Djurelov, M. Kus-ko and A. Radoi	**Mrs. Irina Bratosin**, National Institute for Research and Development in Microtechnologies, **Romania**
19.	Charge injection layers from carboxylic acid molecules. **V. Stará**, J. Planer, P. Procházka, T. Skála, M. Blatnik and J. Čechal	**Ms. Veronika Stará**, Brno University of Technology, **Czech Rep.**
20.	Conductimetric microsensors integrating phthalocyanine nanolayers: high-performance sensing devices for the measurement of NO2 at ppb level in atmosphere. **J. Brunet**, T. Gueye, A. Ndiaye, A. Pauly and C. Varenne	**Dr. Jerome Brunet**, University of Clermont Auvergne, **France**
21.	(Bio)Chemical Stretchable Sensors in Wearable Health Monitors. **M. Moreno**, M. Alique, A. BenAissa and A. Moya	**Mrs. Martina Moreno Fina**, Eurecat, Centre Tecnològic de Catalunya, **Spain**
22.	Preparation of Water-Soluble Microspicule Composition using Hyaluronic acid. **C. Woo Lee**	**Prof. Chul Woo Lee**, Hanbat National University6 Daejeon, **Rep.of Korea**
23.	Antibacterial properties of Polytetrafluorethylene Nanotextile with Ag Nanoparticles Induced By High-Energy Excimer Laser. **B. Frýdlová**, N. S. Kasálková, D. Fajstavr, Z. Kolská , V. Švorčík and P. Slepička	**Ms. Bara Frýdlová**, The University of Chemistry and Technology Prague, **Czech Rep.**
24.	Antibacterial and Photothermal Properties of Silver Nanoparticles: Paving the Way for Targeted Therapeutic Strategies. **L. Hochvaldová**, L. Válková, L. Kvítek, R. Večeřová, M. Kolář3 and A. Panáček	**Ms. Lucie Hochvaldova**, Palacky University- Olomouc, **Czech Rep.**
25.	In vitro characterization of electroactive scaffolds for tissue engineering. **O. Buchar Klinovská**, S. Müllerová and M. Hubálek Kalbáčová	**Ms. Olga Buchar Klinovská,** Charles University, **Czech Rep.**
26.	Tribo-corrosion Evaluation of Electron Beam Melting Ti6Al4V-ELI for Biomedical Applications. **M.D.M. das Neves**, L.C.E. Silva, R.A. Antunes , F.P. da Água, J.O. da Paz and E.F. Pieretti	**Prof. Maurício das Neves**, IPEN, **Brazil**
27.	Nano-texturing and high antibody adsorption of silicon nanoparticle surfaces for clinical application to enzyme-antibody methods. **M. Endra Swe**, T. Iwamoto, Y. Manome and K. Sato	**Ms. Myat Endra Swe**, Tokyo Denki University, **Japan**
28.	Nanostructured system based on hydroxyapatite and curcumin: a promising candidate for osteosarcoma therapy. **J. P. N. Marinho** and E. M. B. Sousa	**Dr. Edesia M. Barros de Sousa**, Development Centre of Nuclear Technology, **Brazil**
29.	Extracellular vesicles as nanocarriers biocoating for enhanced drug delivery in stroke. **A. Oris**, A. Bronckaers, A. Ethirajan and I. Nelissen	**Ms. Anouk Oris**, University of Hasselt, **Belgium**
30.	Star polymers as miR146a delivery system to regulate cardiomyocyte apoptosis after myocardial infraction. **Ł. Przysiecka**, K. Fiedorowicz, K. Szcześniak, B. Grześkowiak, M. Bigaj-Józefowska and G. Nowaczyk	**Dr. Łucja Przysiecka**, Adam Mickiewicz University Poznań, **Poland**
31.	Lipid liquid crystalline nanoparticles as nanocarriers of miR let7g supporting cardiomyocyte maturation. **K. Fiedorowicz**, Ł. Przysiecka, K. Gębicka, D. Flak and G. Nowaczyk	**Dr. Katarzyna Fiedorowicz**, Adam Mickiewicz University Poznań, **Poland**
32.	Nanoembedded Microparticles as an Innovative Drug Delivery System of a Therapeutic Peptide for the Treatment of Heart Failure. **J.Modica**, E.Quarta, L.Degli Esposti, A.Alogna, V. Di Mauro, P. Colombo, C. De Luca, M.Iafisco, H.Post and D.Catalucci	**Dr. Jessica Modica**, CNR-IRGB- Milan, **Italy**
33.	NaYF4:Yb3+/Er3+ upconverting nanoparticles for imaging and therapy. **P. Matouš**, V. Herynek, J. Pankrác, D. Mareková, K. Turnovcová, V. Patsula, D. Horák and L. Šefc	**Mr. Petr Matous**, First Faculty of Medicine, Charles University, **Czech Rep.**
34.	Antitumor activity of HPMA copolymer conjugates bearing docetaxel and platinum-based drug for the treatment of head and neck cancer. **K. Behalova**, D. Starenko, L. Kostka, M. Subr, T. Etrych and M. Kovar	**Ms. Katerina Behalova**, Institute of Microbiology of the Czech Academy of Sciences, **Czech Rep.**

35.	Inhibition of P-gp mediated multidrug resistance and STAT3 signaling pathway by polymeric conjugates bearing HIV protease inhibitor derivatives. **D. Starenko**, K. Behalova, L. Kostka, V. Subr, T. Etrych and M. Kovar	**Mr. Daniil Starenko**, Institute of Microbiology of the Czech Academy of Sciences, **Czech Rep.**
36.	Multiphoton imaging of melanoma 3D models and photothermal therapy in chemoresistant melanoma with plasmonic gold nanocapsules. **Q. She**, P. Zamora-Perez, C. Xiao, M. Sanles-Sobrido, M. Rovira-Esteva, J. Conesa, D. Jaque, H D. Santos, A. Martin, M. Carmen Iglesias-de la Cruz, N. Fernández and P. Rivera-Gil	**Ms. Qiutian She**, Pompeu Fabra University, **Spain**
37.	A new 7-(diethylamino)coumarin and 4-(diethylamino)phenol appended unsymmetrical thiocarbohydrazone: detection of moisture in organic sol-vent and sequential turn-on detection of Cu2+ ions. **K. Santhiya**, B. Murugesapandian and J.V. Gražulevičius	**Dr. Kuppusamy Santhiya**, Kaunas University of Technology, **Lithuania**
38.	Design and Evaluation of an Energy-autonomous Ultra-thin Wireless Sensor Node for Condition Monitoring of Wind Turbine Blades. **T. Schaechtle**, C. Heim, H. Köhler, K. Mader, A. Binder, G. Bruckner, L. M. Reindl and S. J. Rupitsch	**Mr. Thomas Schaechtle,** University of Freiburg, **Germany**
39.	How to deal with low cost air quality sensors? – experiences from the project “Do you know what you breathe?” – educational and infor-mation campaign for cleaner air LIFE-MAPPINGAIR/PL. **T. Sawiński**, A. Drzeniecka-Osiadacz, M. Korzystka-Muskała, M. Kowalczyk and P. Modzel	**Dr. Tymoteusz Sawiński**, University of Wrocław, **Poland**
40.	Structure and bioactive properties of titanium dioxide surface layers produced on NiTi shape memory alloy in low temperature plasma. **J. Witkowska**, T. Borowski, K. Wunsch, J. Morgiel, J. Sobiecki, T. Wierzchoń	**Dr. Justyna Witkowska**, Warsaw University of Technology, **Poland**
41.	*In Vitro* Superparamagnetic Hyperthermia Employing Magnetite Gamma-Cyclodextrin Nanobioconjugates for Squamous Skin Carci-noma Therapy **C. Caizer**, C.G. Watz, I.S. Caizer-Gaitan, C.A. Dehelean, G. Dubalaru and C.M. Soica	**Prof. Costica Caizer,** West University of Timisoara, **Romania.**
42.	Determinants and consequences of PARG inhibitor sensitivity in ovarian cancer; a proteomics approach **A. Almami**, L. Gethings, P. Townsend and S. Taylor	**Ms. Amal Almami**, University of Manchester, **UK**

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SMS 2023 / EGF 2023 / Sensors 2023 / NanoMed 2023 Joint Plenary Session I

The Mechanics of Deformation in Nanocomposites Reinforced with Graphene and other 2D Materials

R.J. Young [1*]
[1] National Graphene Institute & Department of Materials, University of Manchester, Manchester, UK

Abstract:
The deformation and fracture behaviour of one-atom-thick mechanically exfoliated graphene has been studied in detail. Monolayer graphene flakes with different lengths, widths and shapes were successfully prepared by mechanical exfoliation and deposited onto poly(methyl methacrylate) (PMMA) beams. Through in-situ Raman mapping at different strain levels, the distributions of strain over the graphene flakes were determined from the shift of the graphene Raman 2D band. The strength dropped to less than ~10 GPa for large flakes, much lower than the reported value of 130 GPa, thought to be due to the presence of defects [1]. The evolution and propagation of cracks in exfoliated monolayer graphene single crystals and their associated stress fields have also been studied using Raman spectroscopy as a strain sensor. Such stress fields are found to extend over several microns, and their analysis leads to the fracture behavior of graphene being interpreted using linear elastic fracture mechanics [2]. It is shown that propagation of a sharp crack along the zigzag direction occurs at a critical stress intensity factor K_c ~4.0 MPa $m^{1/2}$, similar to the findings of theoretical simulations.
Polymer nanocomposites reinforced with carbon-based fillers are gaining increasing interest for a number of applications due to their excellent properties [3]. This presentation will summarize the current literature status on the mechanical properties of composites reinforced with graphene- and identify the parameters that clearly affect the mechanical properties of the final materials such as the effective length, thickness and modulus of the reinforcement. It will also shown how Raman spectroscopy can be utilized for the understanding of the stress transfer efficiency from the matrix to the reinforcement. Importantly, it will be demonstrated clearly that continuum micromechanics that was initially developed for continuous composites is still applicable at the nanoscale for graphene [4].

Keywords: nanocomposites, graphene, 2D materials, mechanical properties, reinforcement, Raman spectroscopy

References:

1. X. Zhao, D. G. Papageorgiou, L. Y. Zhu, F. Ding, R. J. Young, Nanoscale, 11 14339-14353, (2019).
2. X. Zhao, B. Mao, M. Liu, J. Cao, S. J. Haigh, D. G. Papageorgiou, Z. Li, R. J. Young, Advanced Functional Materials, 2202373, (2022)
3. D. G. Papageorgiou, I. A. Kinloch, R. J. Young, Progress in Materials Science, 90, 75-127, (2017)
4. R. J. Young, M. F. Liu, I. A. Kinloch, S. H. Li, X. Zhao, C. Vallés, D. G. Papageorgiou, Composites Science and Technology, 154, 110-116, (2018).

Nanosurface science: chemical approaches to optical sensors

Tito Trindade[1]
[1]Department of Chemistry and CICECO-Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal

Abstract:

The past decades have witnessed unprecedented progress in the science of nanosized objects, yielding new insights into a variety of materials and pointing new directions for future technologies. It is not an exaggeration to recognize surface phenomena as among the most crucial aspects of these advancements, which continue to reveal a fascinating and complex field for new discoveries. This observation is particularly evident in the case of nanomaterials synthesized and surface-modified as colloids, such as sols composed of tiny particles dispersed in a liquid medium.[1] These nanoparticles show significantly higher specific surface areas when compared to their bulk counterparts. This underscores the emphasis placed on studying their surfaces, often referred to as nanosurfaces. A pivotal aspect of nanosurface science in colloidal particles lies in their capacity for chemical modification, expanding the realm of potential applications and providing versatile platforms for surface research. This lecture offers an overview of our recent work in the synthesis and surface modification of colloidal nanomaterials with distinct structural dimensionality.[2,3] Selected nanosystems are discussed while considering the chemical design of their surfaces, with a focus on envisioning specific functionalities, such as their application in optical sensors. The lecture terminates with prospects for future developments in various types of materials, recognizing that much about nanosurfaces remains to be uncovered.

Keywords: nanosurfaces, nanomaterials, inorganic colloids, graphene materials, macrocycle compounds, Raman spectroscopy, optical sensors, environmental and biomedical applications.

Figure 1: Selected example of multifunctional magnetite nanoparticles (right panel: TEM image; particle anatomy scheme) whose surfaces have been modified with dendrimer macromolecules and gold, envisaging their application in sensors for on-site detection of water contaminants by using Raman spectroscopy (left panel).

References:

1. Daniel-da-Silva, A. L., Trindade, T. (2021), *Surface Chemistry of Colloidal Nanocrystals", Nanoscience and Nanotechnology Series 49*, Royal Society of Chemistry, UK.
2. Monteiro, A. R., Neves, M. G. P. M. S., Trindade T. (2020), Functionalization Routes of Graphene Oxide Using Porphyrins, *ChemPlusChem*, 85, 1857.
3. Fernandes, T., Daniel-da-Silva, A.L., Trindade, T. (2022), Metal-dendrimer hybrid nanomaterials for sensing applications, *Coord. Chem. Rev.* 460, 214483.

Anthracene functionalized nanomaterials for selective and reversible self-assembly of fullerenes

P. Piotrowski[1], A. Krogul-Sobczak[1], A. Kaim[1]
[1] Faculty of Chemistry, University of Warsaw, Poland

Abstract:
Since their discovery in 1985, fullerenes became an important focus in the rapidly developing field of nanotechnology. Solubility in organic solvents, various methods of functionalization, unique structure and electrical properties, for example, reversible reduction with up to six electrons, trigger numerous research projects aimed at developing novel fullerene –based materials including photovoltaic devices, superconductors and field effect transistors.
Due to increasing use of fullerenes and their derivatives their emission to the environment has caught attention of scientists. Their occurrence in environment is both connected with anthropogenic emission and natural sources. The latter are known to be mostly lightnings, volcanic eruptions and wildfires. Taking into account anthropogenic sources, fullerenes were i.e. detected in atmospheric air as products of hydrocarbons burning, but most of their emission is connected with nanotechnology applications. Fullerenes are actually employed in production of numerous nanomaterials, lubricants, cosmetics and food additives, thus their production has grown in recent years. As a result fullerenes were detected in wastewater of industrial areas[1] and few groups have already determined their concentration levels in various environmental samples. It is noteworthy to mention that even the presence of low concentrations should not be neglected as fullerenes behavior and long term effect on aquatic environment is incertitude.
In presented work, we aimed to synthesize novel nanomaterials for both controlled and reversible removal of fullerenes from solution as well as for their detection and quantification at low concentrations. For this purpose we have designed and synthesized series of diverse anthracene functionalized nanomaterials that undergo Diels-Alder reaction with fullerenes.[2,3] The reported procedure leads to formation of well-organized, stable fullerene films on various surfaces. The important advantages of the proposed Diels-Alder approach are the controlled thermal reversibility of binding/release of fullerene moieties and absence of head to tail assembly. Use of obtained nanomaterials allows fullerenes removal from wastewater and/or their analysis after pre-concentration on the electrode surface.
Obtained nanomaterials were investigated using X-ray Photoelectron Spectroscopy (XPS), Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM), Dynamic Light Scattering (DLS) amd thermogfravimetric analysis. Electrochemical characterization was performed using cyclic voltammetry (CV).

Keywords: Fullerene, anthracene, Diels-Alder Reaction, self-assembly.

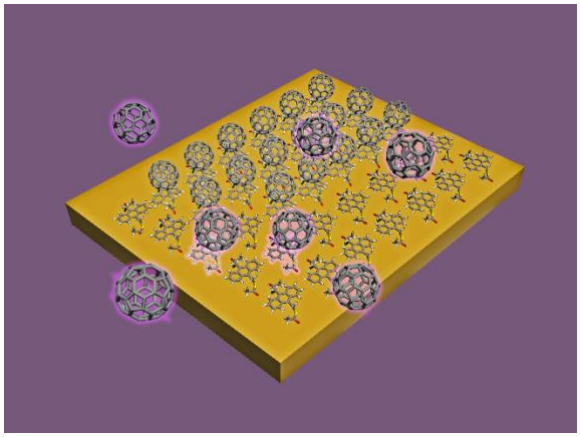

Figure 1: Self-assembled monolayer of di-*S*-acetyl anthracene derivative, which binds C_{60} fullerene via Diels-Alder reaction.

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Effect of gadolinium in the structure of CeO_2

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Abstract:
Rare earth doped ceria is a key material in the terms of the of the growing need of high efficiency energy production, conversion and storage. In this regard, the study of the influence of various rare earth dopants embedded in the basic oxide lattice is an intensively investigated research objective. Pure CeO_2 does not tolerate a significant degree of oxygen transport through its crystal lattice, while the substitution of Ce^{4+} by a proper amount of an aliovalent ion, such as a trivalent lanthanide, promotes the diffusion of O_2- through the oxygen.
In this work, a structural study of Gd doped ceria, performed by XRD, XPS, EPR and IR spectroscopy is presented. The purpose of the investigation is to obtain knowledge of the basic structural features of the system and to confirm the formation of solid solution of $Ce_{1-x}Gd_xO_{2-x/2}$.
The Gd - doped cerium oxides $Ce_{1-x}Gd_xO_{2-x/2}$ (x between 0.1 and 1) are prepared from initial solutions of sodium alginate and metal nitrates ($Ce(NO_3)_3.H_2O$, $Gd(NO_3)_3.H_2O$) by ionic gelation approach. The gel product obtained by this technique is thermally treated at 500 °C, after that the resulting powder is subsequently pressed to pellets and sintered at 1400 °C to produce ceramics.
The performed XRD studies (fig. 1 and fig. 2) reveal the formation of Ce-Gd solid solutions up to some extent. The lattice parameters of the obtained solid solution is determined by Rietveld refinement of XRD data. The elemental compositions of the selected samples are identified from X-ray fluorescent analysis (XRF).
Infrared spectroscopy (FTIR) is used to identify the basic structural units in the obtained samples.
X-ray photoelectron spectroscopy (XPS) results confirms the presence of Ce^{4+} ions in the investi-gated powders. Sodium nitrate impurities are also identified as a biproduct at lower temperature, which could be attributed to the presence of sodium in the alginate precursor.
EPR spectra, recorded by spectrometer Bruker EMX Premium, establishe an increase of the line width of the g-factor in the range of 2.04 to 2.12 with increase of Gd^{3+} content which could be attributed to enhancement of dipole-dipole exchange interactions.
The effect of Gd content as well as calcination temperature influence on the structure-activity properties of CeO_2 were systematically investigated and clarified.

Keywords: gadolinium doped ceria, structure, diffraction, microscopy, spectroscopy, solid solutions.

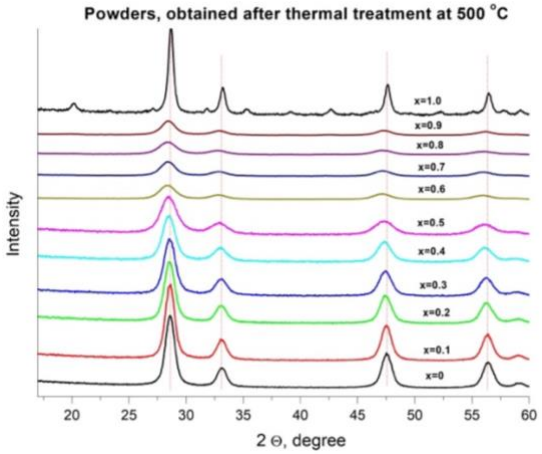

Figure 1: XRD patterns of $Ce_{1-x}Gd_xO_{2-x/2}$ (x = 0 - 1) powders thetmally treated at 500°C.

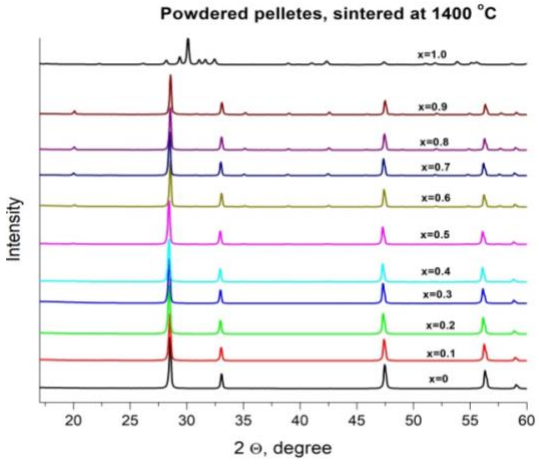

Figure 2: XRD patterns of $Ce_{1-x}Gd_xO_{2-x/2}$ (x = 0 - 1) powders sintered at 1400 °C.

SMS 2023 / Sensors 2023 / NanoMed 2023 Joint Session I. A: Materials synthesis, characterization and properties

Smart Nanohybrids and Multi-material Nanoparticles: Synthesis, Properties, Modeling and Applications

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Abstract:
Many applications of modern nanotechnology take advantage of various properties of smart nanomaterials, such as optical, thermo-, mechano-, magneto-plasmonics, etc., where one property is enhanced or modified due to another [1-3]. Thus, nanoparticle aggregation and fragmentation, formation of bi-metallic, multi-material, alloy, Janus, and/or multi-component nanoparticles pave the way toward extremely wide modification possibilities of their absorption spectra, but also of their physical properties and potential functions in various fields including medicine, solar energy, catalysis, etc.
Ultra-short laser pulses are, furthermore, extremely versatile tools well-suitable for nanoparticle generation and for the following modifications of their sizes, shape, composition, and morphology [2]. Laser absorption and scattering effects rely on their plasmonic properties, but also on their band structure, size, composition, shape, and concentration as well as on the main laser parameters, such as wavelength, intensity, and pulse duration. The following laser-induced phenomena include electronic processes, fast heating, chemical reorganizations, various phase transitions, sintering and/or decomposition, as well as longer relaxation and cooling. Atomistic approaches, such as all-atom molecular dynamics simulations are particularly advantageous for numerical modeling of such systems.
In this study, several examples of laser-induced modifications of smart nano-hybrids, nano-alloys, and multi-material nanoparticles will be presented. Firstly, attention is focused on the initial heating stage accompanied by melting, sintering and/or fragmentation. Then, the cooling is addressed, where phase and species segregation and annealing take place. Size- and composition-dependent particle modifications are thus examined. The obtained results are of interest for the analysis of pulsed laser-induced nanoparticle formation in liquids (PLAL) [1-3], nanoparticle aggregation-fragmentation experiments, sintering, 3D manufacturing, etc.
Particularly, bimetallic nanoparticles, such as AgAu, AlAu, CoAu, and FeAu, CoNi are to be considered. Then, attention is focused on more complex nanoformulations, such as raspberry or core-shell Ni@Au, Au@Ni, Co@Au and Au@Co, Fe@Au and their oxides, their structure, optical, magnetic, and chemical properties, as well as their interests for applications such as cancer theranostics and photocatalysis.

Keywords: femtosecond laser, molecular dynamics, smart nanohybrids, alloys, catalysis, cancer theranostics, solar cells.

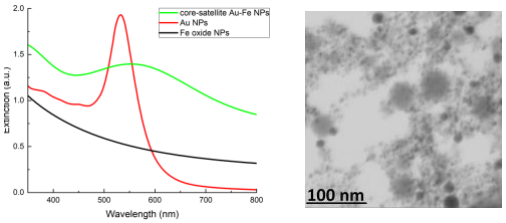

Figure 1: Calculated extinction spectra of bare Au NPs (red line), Fe oxide NPs (black line) and core-satellite Au-Fe NPs (green line) and image of nanostructures formed from laser-ablated Au NPs and Fe NPs in liquids.

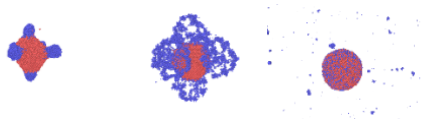

Figure 2: MD simulations of Ni@Au and Au@Ni nanoformulations after laser heating in different regimes.

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Developing sandwich structure with novel biobased composite using additive manufacturing

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Abstract:
Sandwich structures are considered as promising design for structural applications showing high stiffness, low-weight, and high energy absorption properties. In this study, the sandwich panel is designed and fabricated using different plywood as the face sheet and thermoset-based composite as the core. The additive manufacturing (AM) method is employed to print the composite structure onto the plywood surface, enabling precise control over the material distribution and enhancing the bonding between the face sheets and the core. The optimized design and manufacturing process allowed for the integration of a thermoset-based composite core, which contributed to the overall weight reduction of the panel while maintaining its structural integrity. The flexural testing showed significant improvement in the sandwich panel compared to the plywood with the same thickness. The flexural strength and modulus increased up to 3.4 and 3.6 times, respectively. The resulting sandwich panel demonstrated exceptional load-carrying capacity and resistance to bending, making it a viable candidate for various structural applications where weight reduction and high performance are critical.

Keywords: Sandwich panel, composite, lignin, bioepoxy, additive manufacturing.

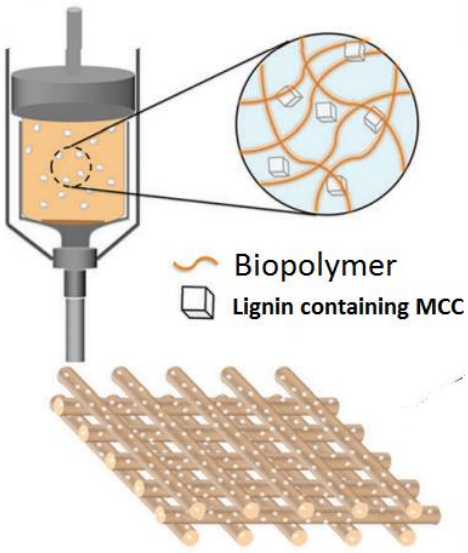

Figure 1: Figure illustrating the 3D printing process of honeycomb structure on the wood surface.

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Functional Block Copolymer Cubosomes with Broad Applicability

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Abstract:
Block-copolymer cubosomes are a novel and rapidly evolving class of mesoporous nanomaterials. They can be synthesized in a scalable manner by bottom-up self-assembly using block copolymers. Cubosomes exhibit bicontinous pore systems which permeate the entire structure. Therefore, they exhibit high surface areas, which is of great interest for many applications (figure 1).[1] However, currently most all cubosomes consist of the chemically inert poly(styrene) (PS), which does not impart any function beyond mechanical stability.[2]
In this work, multiple alternatives to inert PS are synthesized to yield functional polymer cubosomes:
Firstly, poly(4-vinylpyridine) (P4VP) has an addressable nitrogen atom. It can coordinate to various metals and can, for example, be loaded with Pt for catalysis applications. Furthermore, organic substances like drugs can also be loaded and released in a controlled manner by adjusting the pH.[3]
Secondly, mesoporous carbon is one of the most interesting materials in energy storage and conversion, as well as for filtering and purification purposes.[4] However, most synthesis paths require hard templating, HF etching or further toxic and wasteful steps. In contrast, a direct synthesis method was developed here using poly(acrylonitrile) (PAN) based cubosomes.
Finally, organic batteries often suffer from poor performance due to the low porosity of the cathode.[5] By utilizing poly(TEMPO methacrylate) (PTMA) – a common cathode material in organic batteries – a porous cubosome cathode system was developed.

Keywords: polymers, inverse morphologies, self-assembly, electrochemical energy storage, batteries, organic batteries, catalysis, drug delivery, mesoporous carbon, P4VP, PAN, PTMA

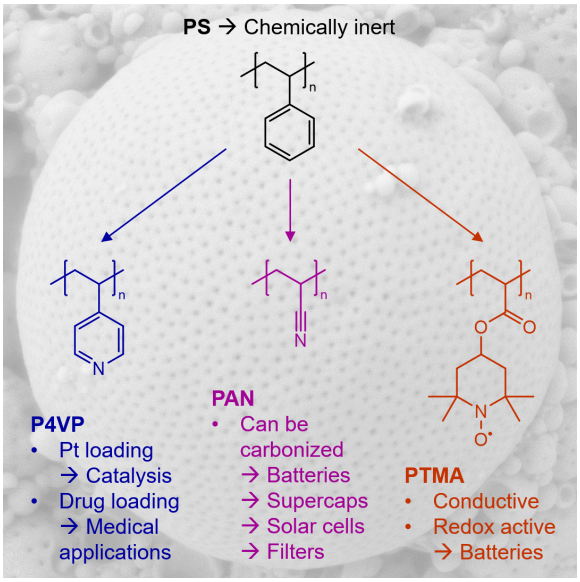

Figure 1: Chemically inert PS and functional polymer alternatives from this work, which can form functional cubosomes. The background is an example of a SEM image of a cubosome.

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3D Nanofabrication of Arbitrary Functional Materials

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Abstract:
Nanofabrication is a revolutionary technology that enables the printing of complex 3D micro-nano structures using functional materials. This technology has shown promising applications in the fields of micro- nanorobotics [1], micro-metamaterials [2], micro-electrodes/microelectronics [3], and micro-nano photonics [4]. Existing nano-printing methods often rely on monomer-based two-photon polymerization (2PP), which significantly restricts the printable materials to a limited choice of polymeric materials, such as commercial inert polymer or a few homemade functional hydrogels. While various non-polymeric materials such as metals [5], quantum dots [6], and metal oxides [7], etc. have been successfully fabricated at the nano/micro scale, each material either requires special chemical designs or has to mix with a cross-linkable polymeric precursor to achieve printability. A general nano- printing method compatible with versatile functional materials still remains a big challenge.
Herein, we propose a new versatile strategy (illustrated in Figure 1) to address the nanoprinting of multifunctional materials. The strategy involves controlling the 3D hierarchical assembly and abundance deposition of nanomaterials onto a 2PP-printed polymer skeleton through a physically-enabled accumulation process. The ability to print complex 3D nano/microstructures with a wide range of functional materials opens up new possibilities for advanced micro-nano systems, paving the way for fabricating smarter, more complicated, and multifunctional microrobots, microdevices, etc. than ever before.

Keywords: 3D nanoprinting, multifunctional nanomaterials, microrobots, microdevices, deposition, assembly

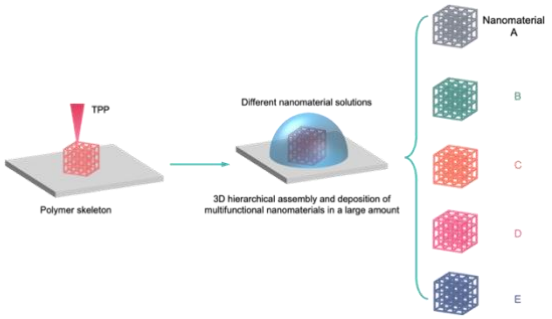

Figure 1. Schematic of multifunctional 3D nanoprinting via assembly and deposition of nanomaterials onto polymer skeleton.

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Investigation of parameters setup efficiency during abrasive waterjet turning of different materials

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Abstract:
The abrasive waterjet turning (AWJT) is not very conventionally used method of material machining. The process seems to be inefficient and too expensive to be widely used in the industrial applications. However, we cannot say yet that AWJT is impasse of the abrasive waterjet research since no complex study of machining different and hard to turn materials has been performed. The increasing use and profitability of machining with an abrasive water jet can be linked to the development of new materials that are less suitable to machine with conventional methods. Composites or nickel superalloys can serve as an example of such materials. The purpose of this research is to find ideal combination of machining parameters, so the efficiency of the process is maximized. As the basis of these experiments, previous analyses and models of abrasive waterjet cutting, turning and description of the deformation process of the material were analyzed. Based on these data, influence of several quantities, such as time of action of the jet, rotational speed, lateral jet shift and traverse speed were tested and evaluated. Different steel types and composite materials were used to perform the research. Traverse speed seem to have high impact on the amount of material volume removed. On the other hand, rotational frequency doesn't belong to significant parameters of the process.

Keywords: abrasive waterjet, material machinability, erosion, deformation and cutting wear, trajectory of the jet in material, angle of impact, effectivity of the erosion, industrial applications.

Figure 1: Photo of tangential abrasive waterjet turning. The deflection of the jet visible in the picture is important phenomena, which may show that the set up parameters of the machine are not able to turn material to the desired diameter. Multipass trajectory was chosen to perform the machining. Special lathe with Lenze engine was constructed and used for this purpose.

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Reconfigurable micro-metastructures with wide-spectrum programmability actuated by hydrogel muscles

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Abstract:
The ability of metamaterials to dynamically change properties and exhibit exotic functionalities through stimuli-responsive geometric transformations is highly desirable. However, achieving diverse final configurations from a single geometry using existing transformation mechanisms remains a challenge. This limitation in programmability imposes significant design restrictions, hampering the realization of versatile functionalities. To address this, we propose a programmable strategy for wide-spectrum reconfigurable micro-metastructures by leveraging linearly responsive transparent hydrogel muscles. Unlike the commonly used hydrogels, our developed hydrogel muscles overcome issues such as non-linear deformation and opacity. The actuation of these hydrogel muscles initiates a transformative process in micro-metastructures through collaborative buckling of their constituent building blocks. By carefully designing three-dimensional printing parameters and geometry features, we can achieve locally isotropic or anisotropic deformation in the metastructures, thereby enabling precise control over a wide range of pattern transformations and chirality. Moreover, this reconfigurable mechanism can be extended to various materials with diverse mechanical properties. One notable application of our strategy is the creation of a printed meta-lattice capable of pixel-by-pixel mapping, allowing for thermal reconfiguration to display or conceal complex information (**Figure 1**). This strategy opens up unprecedented opportunities in areas such as encryption, miniature robotics, photonics, and phononics applications.

Keywords: Micro-metastructures, reconfigubility, hydrogel, encyption, programmability, patterns.

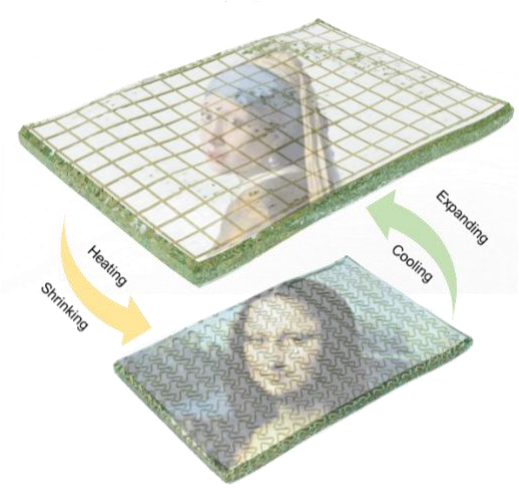

Figure 1: Schematics of the reversible thermal actuation of the micro-metastructures displaying dynamically changed encrypted complex information.

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Investigation of Nonreciprocal Metasurfaces: Exploring Simple Structure and Smart Functions.

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Abstract:
In this research, we investigate novel materials that exhibit non-reciprocity in the propagation direction for controlling radio waves using metasurfaces. Metasurfaces are planar materials that artificially manipulate radio waves, and numerous studies have focused on controlling radio wave characteristics such as frequency, phase, and amplitude differences. However, there have been limited proposals for materials capable of controlling propagation direction when radio wave characteristics are identical. Although a method utilizing a pair of antennas exists, it encounters challenges in achieving a thin and flat structure.
Therefore, our group proposes a method employing cylindrical ferrite magnetic material and metal foil to address this issue. Despite its simple structure, this method offers broad frequency characteristics depending on the size of the ferrite and its material constants. Moreover, by arranging the shape of the metal foil and incorporating active circuit elements, it is possible to achieve electrical control over the transmission and reflection of radio waves. In this report, we present the findings of our investigations into optimizing the thickness and electrical control parameters for realizing thin flat plates.
Figure 1 illustrates simulation results obtained using the CST electromagnetic field simulator, depicting unit cell conditions and the definition of nonreciprocity. The analysis of the unit cell demonstrates that the flat plate achieves a transmission of -2.5 dB at 8 GHz, while providing an isolation of 17 dB. Consequently, it is confirmed that transmission in the opposite direction can be effectively blocked while maintaining a transmission level of -3 dB or higher. The thickness of this material corresponds to the ferrite diameter and, although it varies with frequency bands, our analysis indicates that it can operate even at a maximum of approximately 1/8 wavelength.
Additionally, simulations utilizing an equivalent circuit with the PIN diode switched ON/OFF confirm that while the bandwidth narrows, the same level of isolation can be achieved.

Keywords: artificial micro structures, metamaterials, metasurfaces, nonreciprocity, electrically control materials.

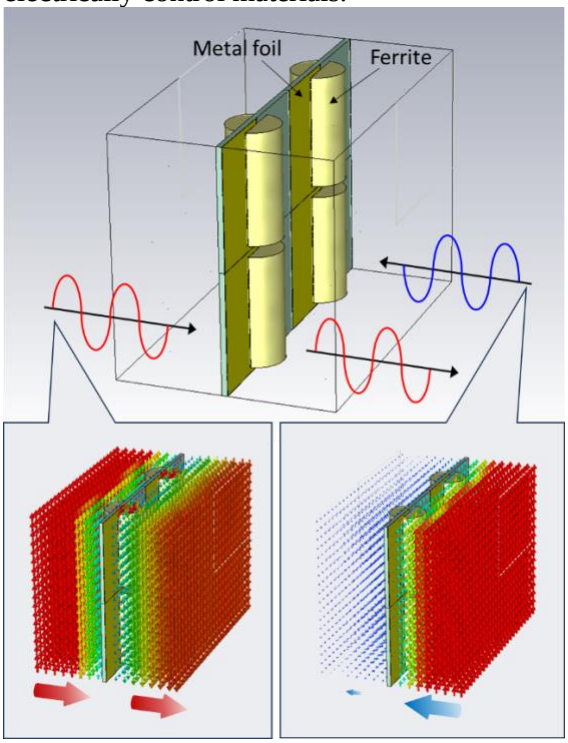

Figure 1: The upper figure represents a unit cell analysis model that simulates a pseudo infinite surface,with the proposed structure being represented as 2x2. The lower left part and lower right part show the example of the analysis results in the transmission direction and in the blocking direction, respectively.

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Packaged fiber Bragg grating strain sensors for railway traffic monitoring

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Abstract:
In numerous industrial applications, fiber Bragg gratings (FBGs) are preferred to classical sensing solutions. Their main advantages rely in accuracy and reliability for e.g. strain, temperature and pressure sensing in rough environments, but also in a context where electrical components present a safety risk or where the use of small sensors is a requirement. In the domain of railway traffic monitoring a special focus is paid on FBGs since the first experimental report confirming their capability of axles detection[1].

Classical solutions for railway safety mainly consist of track circuits (device able to detect the presence of a train as well as a rail breakage) and axle counters (placed at both ends of a rail section to count the axles present within this section). Besides these solutions, potential emerging technologies are investigated through research. Thanks to their intrinsic assets (electromagnetic immunity, low attenuation, robustness, small size, real-time demodulation, remote interrogation of tens of sensors along a single fiber, etc.) FBGs have been largely studied for railway monitoring. Along the tracks, FBGs effectively act as axle counters[1,3–9] and can bring extra features such as weigh-in-motion monitoring[10], structural health monitoring (SHM)[11,12] and wheel flat detection[13]. Even if the technology readiness level is undeniably increasing, there is still progress to make before a massive industrial commercialization in the frame of railway monitoring.

In our work, two relevant originalities are proposed, compared to the state-of-the-art solutions, to bring the technology to a real practical implementation. First, the strain distribution over the rail cross-section is studied to identify the sensitivity, depending on the charge and the position. Secondly, a sensor head, composed of four packaged and wavelength-division-multiplexed FBGs in a single optical fiber, is deployed along the railway and interrogated by a dedicated read-out device. Two FBGs are used to determine the train direction while the remaining two bring redundancy to reach safety integrity level (SIL) 4. Each sensor is embedded into a specific packaging that is glued on the foot of the railtrack, as depicted in Fig. 1. The high-speed data acquisition system BSI-108 from B-SENS has been used. The processed FBG response is depicted in Fig. 1, from which the number of axles (corresponding to the peaks) can be inferred. This information can be wireless communicated. On-field experiments confirm that this approach brings an easy installation and a democratization of the technology.

Keywords: optical fibers, fiber Bragg gratings, strain, traffic monitoring, safety.

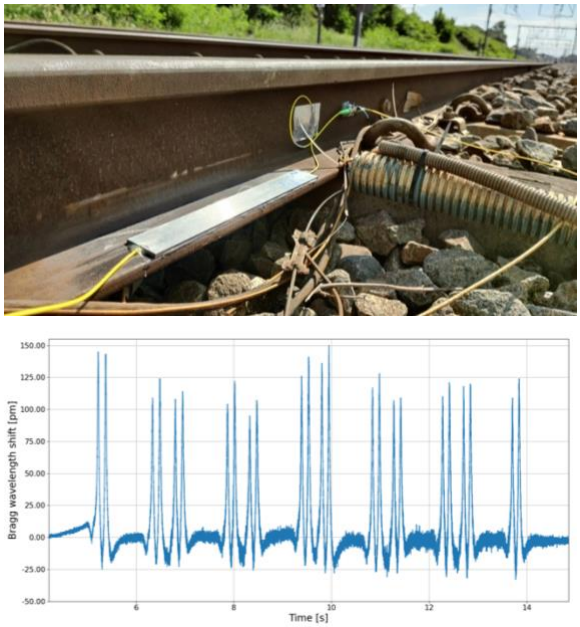

Figure 1: Packaged FBG strain sensors glued on the foot of the rail (top) and typical FBG response as a function of time showing the axles detection (bottom).

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Design and Additive Manufacturing of Newly Developed Mechanical Metamaterials for Structural Applications

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Abstract:
Mechanical metamaterials are architected structures with unique mechanical properties usually not found in conventional materials. Their mechanical properties are mainly defined by the geometry of the structure. These properties include, but are not limited to, negative Poisson's Ratio, lightweight, variable stiffness, compliancy and foldability. This variety opens new prospects for engineering and functional designs for structural applications. Herein we present the design, additive manufacturing and mechanical testing of newly developed mechanical metamaterials. Figure 1 shows a new kind of bending dominated structure with independently tunable stiffness in the three spatial directions. Therefore, structures with tunable orientational properties can be designed, ranging from isotropic to anisotropic structures. By introducing an asymmetry into well established chiral-based metamaterials, we were also able to increase the tunabilty of the Poisson's Ratio, Young's modulus and porosity of such structures. Similar designs also allow for tunable normal-strain shear coupling effects in compliant structures. Different additive manufacturing techniques were used to manufacture polymer-based specimens, namely Fused Filament Fabrication, Digital Light Processing and Selective Laser Sintering. The properties of the structures were determined by means of mechanical tests. Additionally, numerical models were developed to verify the applicability of simulations to represent the mechanical tests and to investigate the influence of the geometric parameters onto the mechanical properties. The numerical simulations were accompanied by machine learning tools to reduce the computational cost. Neural networks were developed to further investigate the influence of the geometric parameters and served as a tool for optimization strategies.

Keywords: metamaterials, design, additive manufacturing, tunability, mechanical testing, numerical simulations, machine learning, neural networks, mechanical properties, Poisson's ratio, Young' modulus, porosity

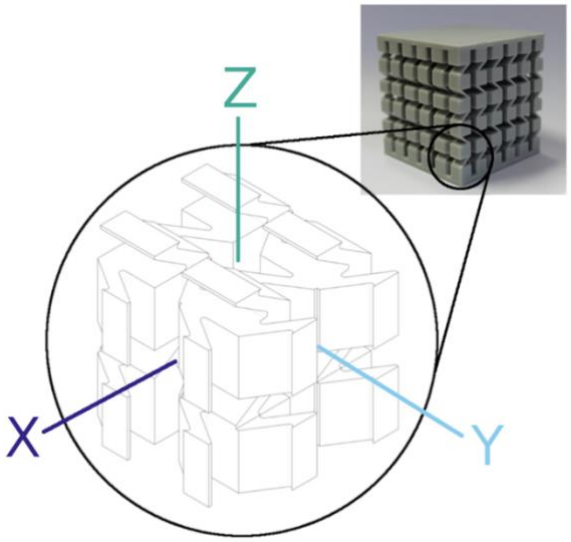

Figure 1: Design of a mechanical metamaterial with independently tunable stiffness in the three spatial directions. The stiffness can be varied in the range of several orders of magnitude. Gradual transitions from one unit cell to the next can be realized, enabling smooth transitions from soft to hard regions.

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Manufacturing of Soft Dielectric Actuator by multi-material Fused Filament Fabrication

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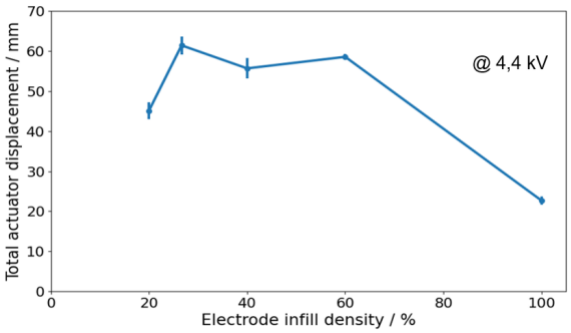
Abstract:
3D printing in field of Soft Dielectric Robotics is still not researched completely. The first partially FFF (Fused Filament Fabrication) 3D printed soft dielectric actuator (DEA) is reported in 2019 [1]. The technical characteristics, such as actuation displacement and actuation force were not sufficient for the practical use of the 3D printed DEA. Other 3D printing technologies apart from FFF, are usually more expensive or they have more manufacturing steps. Those facts were an inspiration for this work.
In order to 3D print DEA, it was obligatory to find suitable 3D printing filaments, which sometimes need to have contractionary properties, like good high filler content for good electrical conductivity and low stiffness. Our working group already reported the first fully FFF 3D printed DEA [2]. It is importatnt to single out, that the whole DEA is manufactured in one printing job. Further development of our own electrically conductive polymer composite for FFF enhanced the DEA performances. Within this work the multi-material FFF 3D printing parameters were optimized (Figure 1a). The geometry of the essential actuator parts is improved, that the 3D printed DEA can achieve larger actuation movements.
The newest outcome of our work is a maximum displacement of 109% (Figure 1b) and the the fully FFF 3D printed unimorph DEA with locking/unlocking possibility via shape memory effect.

Keywords: dielectric elastomer actuator, fused filament fabrication, soft dielectric actuator, electrode optimization, soft robotics, development of electrically conductive composite, shape memory polymer.

a)



b)

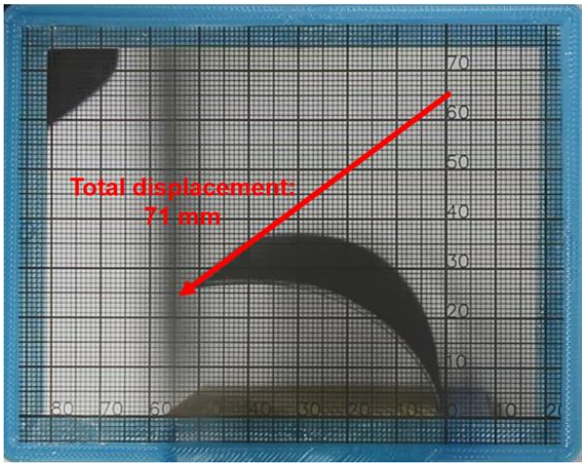


Figure 1: a) The dependence of the electrode infill density to the total actuator displacement.; b) The fully FFF 3D printed DEA reached its maximum displacement.

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From unit cells to multifunctional components – 3D printed metamaterials

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Abstract:
At present, metamaterials are increasingly being applied in various industries such as automotive, aerospace or medical devices. They are readily used due to their lightweight, very unique mechanical properties and possibility to create more energy-efficient devices than traditional ones. Metamaterials are usually designed as repeating patterns that consist of unit cells. Their unusual mechanical behavior (for example negative Poisson's ratio) is derived from the structural design. Cellular architecture enables low density of the component and tailorable mechanical behavior, such as stiffness, strength, and energy absorption. Mechanical properties can be adjusted through geometry of the unit cell, base material and geometry variation. The complex geometry of metamaterials can be produced by additive manufacturing.

This study shows the current research status at Polymer Competence Center Leoben – from architecture of unit cells to 3D-printed polymeric components.

One example are sandwich components applied in plane cabines. The construction is composed from a lattice core structure and a laminated surface part. The carbon fibre reinforced (CFR) laminate provides improved strength, high modulus of elasticity, good fatigue and abrasion resistance. The lattice core reduces significantly the weight.

Keywords: additive manufacturing, 3d-printing, lattice structures, mechanical metamaterials, lightweight conctructions, multifunctional composites

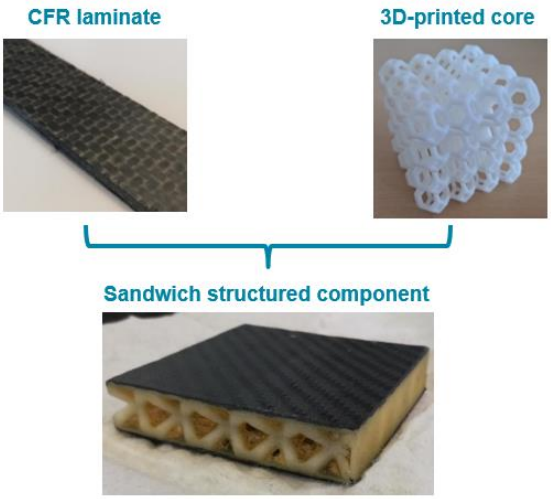

Figure 1: Sandwich structured component created from carbon fibre reinforced polymer laminate and 3D-printed lattice core.

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Production and Reforming of Glucose into High-Value Chemicals Using Nanostructured WO_3 and WO_3/TiO_2 photoanodes

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Abstract:
In the most frequently used hydrogen-producing photoelectrochemical (PEC) cell configuration, water reduction occurs at a metallic cathode and is accompanied by photo-oxidation of water at an n-type semiconductor photoanode. The efficiency of such PEC device relies critically on the kinetics of the photoanodic reaction in which photogenerated positive holes (h^+) are scavenged by water molecules to allow effective transfer of photogenerated electrons (e^-) to the cathode. A broadly discussed approach intended to enhance efficiency of hydrogen generation in the PEC device consists in replacing oxygen evolution reaction occurring on the photoanode by a kinetically easier photo-oxidation of organic substrates, including biomass derivatives. However, an optimal implementation of such concept would require, rather than total mineralization at the photoanode of the used organic reagent to form carbon dioxide, its conversion into value-added products. This presentation will focus on a PEC device employing a nanostructured WO_3 and/or a hybrid WO_3 /TiO_2 photoanode, which irradiated with simulated AM 1.5G solar light, achieves high photocurrents reaching 6.5 mA cm^{-2} through photo-reforming of glucose, a common carbohydrate available in nature that can be obtained by processing waste biomass[1]. The very high achieved anodic currents are in important part due to the occurrence of the photocurrent doubling, where oxidation of glucose by the photogenerated positive hole is followed by injection by the formed intermediate of an electron into the conduction band of WO_3. We show that selection of an appropriate supporting electrolyte enables effective reforming of glucose into valuable chemicals: gluconic and glucaric acid, erythrose and arabinose while practically avoiding its total mineralization. By employing a hybrid WO_3 /TiO_2 photoanode, making possible use of a neutral electrolyte pH, the total faradaic efficiency of the four principal glucose reforming products exceeded 64%. Due to the nano-porous nature of the employed photoanode[2] minimizing the bias voltage, allowing the photoanode to reach plateau photocurrent at ca 1 V, it is possible to combine such PEC cell with a single-junction photovoltaic (PV) cell to form a tandem device[3]. This is facilitated by the semitransparent nature of the WO3 photoanode. The large photocurrents (above 6 mA cm^{-2}), achieved in the PEC cell, translate into expected solar-to-hydrogen efficiency above 7% to be attained in the tandem device.

Keywords: photoelectrochemistry mesoporous tungsten trioxide WO_3, titanium dioxide TiO_2, hybrid WO_3/TiO_2 photoanode, glucose photo-oxidation.

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Development of electroanalytical devices for assessment of food safety and quality parameters in fish and shellfish

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Abstract:
Food safety and quality are a global concern that requires decentralized analytical methods for rapid and on-site determinations, especially regarding microbiological and chemical contamination as well as the presence of allergens. One of the causes of foodborne illnesses is biogenic amines with histamine and tyramine considered the most toxic [1]. In the allergens field, tropomyosin is the major shellfish allergen commonly found in the muscles of crustacean species [2]. Heavy metals are recognized as a major source of environmental pollution and can be absorved by fish and seafood. Among these metals, lead and cadmium represent a major public health concerns due to their high toxicity, even at low concentrations [3]. Therefore, the development of analytical tools capable of quantifying these biogenic amines, allergen and heavy metals in a simple, rapid and decentralized way will contribute to guarantee food quality and safety throughout the entire production chain. This study presents the development of miniaturized electroanalytical devices based on small-sized tranducers, such as commercial screen-printed electrodes, or hand-made electrochemical cells (Figure 1) including: (i) enzymatic sensors for histamine and tyramine analysis, (ii) an immunosensor based on a sandwich-type assay for tropomyosin determination, and (iii) the simultaneous analysis of cadmium and lead. These sensors were applied to the analysis of several foods and food products.

Keywords: Biogenic amines, food allergen, heavy metals, electrochemical biosensor, sensor, food quality

Acknowledgements:
This work received financial support from Portuguese national funds (FCT/MCTES, Fundação para a Ciência e a Tecnologia and Ministério da Ciência, Tecnologia e Ensino Superior) through projects UIDB/50006/2020 and UIDP/50006/2020. E. Costa-Rama thanks for the support of the grant "Beatriz Galindo" (BG20/00027) funded by the Ministry of Universities of the Spanish Government. R. Torre thanks FCT and ESF (European Social Fund) through POCH (Programa Operacional Capital Humano) for her PhD grant (SFRH/BD/143753/2019).

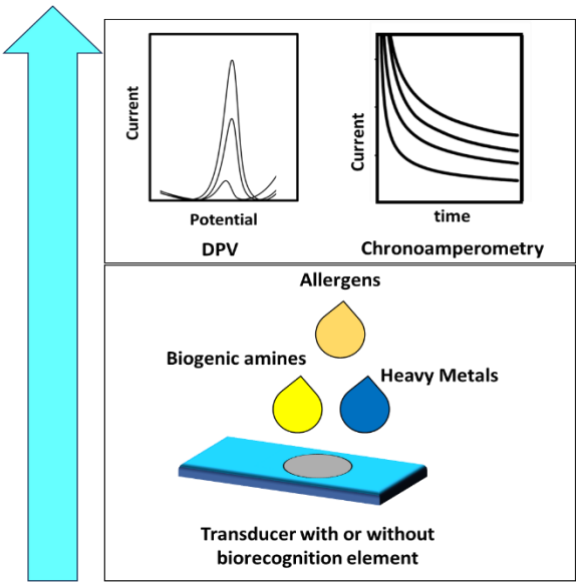

Figure 1: Scheme of the strategies adopted for the determination of biogenic amines (histamine and tyramine), an allergen (tropomyosin) and heavy metals (lead and cadmium).

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SMS 2023 / NanoMed 2023 - Session I. B: Smart coatings and Surfaces / Biomaterials

Effect of cold plasma process parameters for organosilicon deposition on corrosion protection performance

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Abstract:
Plasma enhanced chemical vapour deposition (PECVD) process enables deposition of thin films of controlled physico-chemical properties using a variety of different organosilicon precursors. Its advantages are the wide range of settings and changeable parameters such as the gas flow rates, the gas ratio the type of plasma used, which enable to accurately control the growing film characteristic. The organosilicon films formed using PECVD are mostly amorphous in nature and usually associated with a high electrical resistivity. In this work, the barrier properties of organosilicon coatings against corrosion were investigated. Corrosion resistant coatings protect metallic components against degradation due to moisture, salt spray, oxidation or exposure to a variety of environmental or industrial chemicals.

In this work, the films were deposited on carbon steel using a PECVD process (Figure 1). In order to study the behavior of corrosion protection of organosilicon coatings prepared from cold plasma polymerization of 1,1,3,3-Tetramethyldisiloxane (TMDSO). The effects of several parameters such as nitrogen, oxygen, and monomer flow rates, microwave power and deposition time were investigated based on an experimental design. The corrosion tests were performed by immersing the uncoated and coated carbon steel samples in 3% NaCl at 30 °C.

The structural properties of the deposited films were analysed using different methods such as Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Cross-cut, Contact angles measurements and Profilometery.

The coatings were found transparent, dense, and free of cracks with very low porosity and thicknesses of around 5 µm. The protection efficiency against corrosion of the deposited films has been demonstrated by coupling different electrochemical techniques such as Open Circuit Potential and Electrochemical Impedance Spectroscopy (EIS) in 3 wt% NaCl.

The results clearly demonstrate that the obtained films provide very good barrier against corrosion and show that the protective efficiency of layers persists for long immersion times in the aggressive environment [1].

Keywords:
Cold Plasma, organosilicon coatings, carbon steel, corrosion, SIE, SEM

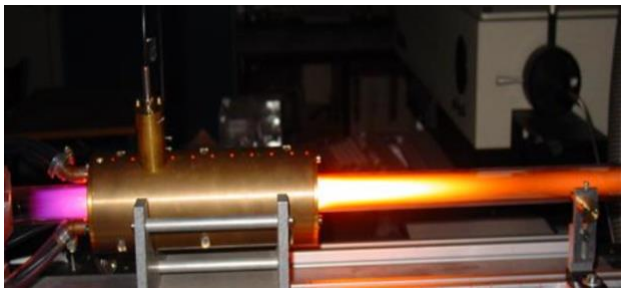

Figure 1: Nitrogen plasma afterglow

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Plasma Electro Oxidation technology as a clean and efficient alternative for the development of advanced coatings on light alloys

R. Bayón[1], P. Fernández-López [1], S. Alves[1], E. Gutiérrez-Berasategui[1]

[1] TEKNIKER. Basque Research and Technology Alliance (BRTA)

Abstract:

Aluminium (Al) alloys have been increasingly used in different industrial sectors such as aviation, shipping, aerospace and automotive towards the development of new lighter and high-performance components [1]. Notwithstanding their outstanding properties, the key limiting factor for its wider use is that Al display poor tribological properties, suffering wear and degradation when exposed to aggressive environmental conditions. Several electrochemical surface treatments are currently employed to treat Al-based materials and overcome the existing limitations such as hard anodizing, chrome plating, nickel electroplating and electroless nickel plating. Besides the attractive functional properties of the current coatings, there are several environmental, safety, and health issues that the correspondent production processes face, compromising sustainability in different dimensions.

Over the past years, Plasma Electro Oxidation (PEO) has appeared as a novel technology with a very high potential to overcome the issues faced with conventional electrochemical coating technologies [2], [3]. Contrarily to traditional electrochemical treatments, this technique is widely known due to is cleanliness as it employs aqueous eco-friendly alkaline electrolytes free of toxic substances. These electrolytes are based on (potassium or sodium)- hydroxide, phosphate, and silicate, which are all food grade chemicals with no risk to human health.

PEO technology is successfully used on light alloys (Al, Ti, Mg) for different industrial sectors, although in the case of aluminium alloys it has a greater industrial projection since this material is present in a large number of components for all industrial sectors [4], [5].

The aim of this work is to show the characteristics and main properties of different coatings developed using PEO technology on different substrates, for different industrial applications and using both AC and pulsed bipolar sources during the process.

Keywords: Al-Si alloys, Ti alloy, plasma electrolytic oxidation, multifunctional coatings, lightweighting

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Novel PEO coatings developed on a secondary cast Al-Si alloy under pulsed bipolar polarisation for brake applications

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Abstract:
Due to their outstanding properties, cast aluminium-silicon (Al-Si) alloys are being applied in several industrial sectors for the development of lightweight components, particularly in the transport sector, where the reduction of weight is a strategic approach to minimize fuel consumption [1].
Despite their excellent castability and high mechanical properties, cast Al-Si alloys present poor wear and corrosion resistance, which hinders their use for critical components with stringent requirements [2, 3]. Plasma Electrolytic Oxidation (PEO) technology constitutes a promising technology for the obtention of protective coatings on light alloys. However, the p-semiconducting behavior of silicon phases and complex intermetallic compounds in cast Al-Si alloys make it challenging to develop PEO coatings with proper mechanical properties [3].
This study is focused on the development of PEO coatings on a heterogeneous secondary cast Al-Si alloy for brake disc-related applications. Throughout the application of a pulsed bipolar polarization regime and the optimization of both the electrical parameters and electrolyte composition, dense and thick coatings have been developed. The obtained PEO coatings have been characterized in terms of thickness, roughness, chemical and phase composition, hardness, and energy consumption.
The tribological performance of the novel PEO coatings have been evaluated by means of a specific tribometer that mimics the bake pad to disc contact pair. In order to assess coating feasibility for this application, the tribological behaviour of PEO-coated Al-Si discs have been compared against that provided by cast iron, which is commonly applied in brake discs. Furthermore in real applications, brake pad-disc wear often occurs under adverse weather conditions which promote corrosive environments. Therefore, tribocorrosion tests have been also carried out for performance evaluation of the PEO coatings developed for brake applications.
The present study presents new insights for the development of PEO coatings with high tribological performance on a secondary cast Al-Si alloy. From the results obtained, PEO technology is envisaged as an efficient alternative to extend the service life of cast Al-Si automotive components, making them competitive against the use of heavy cast iron parts.

Keywords: secondary cast Al-Si alloys, plasma electrolytic oxidation, coatings, lightweighting, tribology, tribocorrosion, brake applications.

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Multi-scale Simulation of Oxidation Effects on Wetting Properties of Fentosecond Laser-treated Surface

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Abstract:
Ultra-short laser pulses are used to texture various surfaces producing micro- and nano-scale reliefs on materials resulting in an increased surface area and enhanced surface energy [1]. This kind of surface treatment has many advantages, such as the reduction of thermal effects and the minimization of surface contamination. These textured surfaces have found diverse applications in viruses and bacteria repulsion, including the osseointegration process in biomedical implants [2].
One of the known challenges is also the fact that surface properties can be unstable and evolve with time. In fact, despite the high versatility and efficiency of laser treatment, it can favor surface oxidation or induce chemical modifications leading to changes in wettability over time. The underlying reasons for these changes are, however, not yet understood [3].
To shed light on these effects, we have performed a series of reactive all-atom molecular dynamics (MD) simulations to investigate the impact of early oxidation on laser-treated titanium (Ti). Additionally, computational fluid dynamics (CFD) is used to quantify droplet behavior on laser-textured metal surfaces [4]. The MD simulations were carried out at several temperatures ranging from 100K to 1000K. The obtained calculation results show how the thickness of the resulting oxide lyers increases with time at different temperatures (fig. 1a). Among the results, we note that the TiOx layer exhibits faster growth in the beginning (at 0–130 ps), as compared to the later stages (130–300 ps). The obtained results are then employed in a series of wetting simulations, including droplet behavior on Ti and Ti with TiOx layer/inclusions. The simulations reveal that the presence of oxide reduces the hydrophobicity of the droplet, which is consistent with several experimental observations. In fact, the contact angle decreases over time (fig. 1b.) due to the increasing thickness of the oxide layer [4]. This effect becomes more pronounced at higher temperatures [5].
In summary, the analysis of the obtained results provide several new and original explanations of the surface wettability switching effect and its time evolution after ultra-short laser treatments. The calculated dynamics of the early titanium oxidation correspond to the measured early time evolution of surface wettability in laser-treated materials. The results are particularly interesting for laser treatment of dental implants, and scaffolds, as well as of many other surfaces commonly used in automobile and aerospace industries.

Keywords: femtosecond laser, oxidation, wettability, reactive molecular dynamics, computational fluid dynamics.

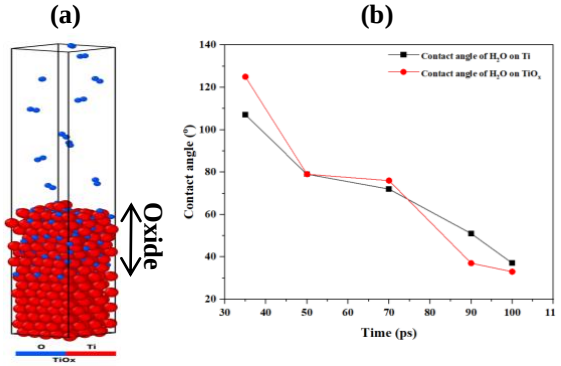

Figure 1: (a) Oxidation process of Ti, and (b) wettability of Ti and TiOx as a function of time.

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Laser-based production of anti-stick coatings on CFRP rolls

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Abstract:
Replacing conventional roll materials such as steel or aluminum with functionally coated lightweight rolls made of CFRP can minimize energy consumption, due to the weight savings, and effectively increase service life of rolls, motors and bearings [1]. Such coatings can be, for example, anti-stick coatings used in production plants in the field of hygiene article manufacturing, the packaging industry as well as automotive industry.
In the moment, however, anti-stick coatings can only be applied to CFRP components to a limited extent. Wet-chemically applied, sol-gel-based anti-stick coatings have to be thermally cured, e.g. by means of an oven process. However, the temperature required for this (200 – 300 °C) exceeds the maximum permissible temperature of the CFRP substrate (80 – 120 °C). Thermal curing at CFRP-compatible temperatures is thus only incompletely possible, resulting in insufficient coating functionality. Alternative anti-stick coatings made from high-performance polymers must be melted at temperatures above 250 °C after powder or spray application. The necessary melting temperature also exceeds the permissible temperature of the CFRP substrate, which means that conventional production on CFRP components is only possible with polymers with very low melting or crosslinking temperatures (e.g. silicone). However, these are very soft and offer little protection against abrasion processes occurring in production plants.
Laser treatment overcomes the disadvantages of conventional oven-based processing, as the fast heating and cooling rates allow the required temperatures to be reached in the layer while reducing the thermal load on the substrate material. This study shows the laser-based production of sol-gel-based and polymeric-based high-performance anti-stick coatings on CFRP rolls without damaging the CFRP base material. The energy consumption to produce these coatings is lower, than using an oven-based process since only an area close to the surface is heated and not the entire component. Furthermore, the interaction time for processing the layers can be significantly reduced compared to the oven process.
The focus of the study is to characterize the functional properties of the coatings (contact angle, hardness, adhesion) after laser processing.

Keywords: Laser-based Processing, Non-Stick Coatings, Polymer Coatings, Sol-gel-based Coatings

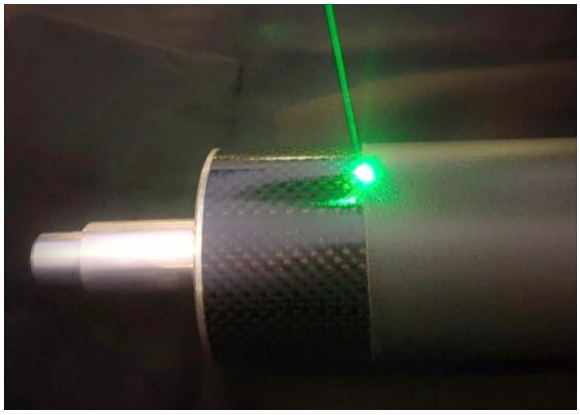

Figure 1: Sol-gel-based anti-stick-coating on a CFRP roll produced with a laser-based process

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Innovative Solar Thermal Collector Coatings for Improved Mechanical Properties and Energy Efficiency

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Abstract:
The reduction of greenhouse gas emissions is crucial nowadays, the efficient use of solar energy being essential for the transition from fossil fuels to renewable energy sources. Solar radiation is already frequently utilized to fulfill the energy demands for residential heating and cooling. Different technologies, focusing on effectively converting solar energy into thermal energy, are available in various stages of development. One approach to achieve this is through high-selectivity solar thermal collectors, ideally designed to absorb solar radiation in the spectral range of 0.25 μm to 2.5 μm, while minimizing thermal emission in the range of 2 μm to 25 μm. Multiple strategies involve optimizing multilayer structures composed of thin films with varying thicknesses to enhance resistance to high temperatures (~ 500 °C) while improving both mechanical and optical properties. A potential solution consists in varying the number and thickness of individual thin layers, and their elemental compositions while reducing the metal content from the substrate towards the final layer. In the present study, each layer's role within the multilayer structure is defined. Chromium has a major contribution to enhancing adhesion and infrared reflectivity, whereas the the unique optical properties are given by the titanium-silicon-chromium nitride and oxynitride layers. The multilayer stack also serves as an interference filter with varying refractive indices, enabling color control. The multilayer structure's optical properties, both before and after heat treatment at 500°C, are investigated, showing an increase in solar absorptance and thermal emissivity values. Structural analysis by X-ray diffraction reveals that the films exhibit a high degree of amorphization due to the substantial atomic size differences between the constituent elements. The as-deposited multilayer exhibits a sharp increase in friction coefficient at a maximum force of 9 N, whereas the heat-treated multilayer displays stable behavior up to a 20 N applied force.

Acknowledgments: This research was funded by the Romanian Ministry of Research, Innovation and Digitalization through the National Research Development and Innovation Plan 2022-
2027, Core Program, Project no: PN 23 05, contract no PN11N-03-01-2023, and through Program 1- Development of the National Research-Development system, Subprogram 1.2 - Institutional Performance - Projects to Finance the Excellent RDI, Contract no. 18PFE/30.12.2021.

Keywords: solar energy, mechanical properties selective absorbing coatings, multilayer structures, optical properties, adhesion, nitrides.

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Anti-microbial surfaces for use in aircraft cabins

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Abstract
Globalization and the ability to travel all over the world within no time by aircraft were the decisive reasons why the Corona virus was able to spread so quick everywhere. Due to this risk air traffic decreased 2020 by 75% (in Germany). The DLR-projects *germfree flying* and *FIONA* are focused on the development of germ-free cabin surfaces to avoid disease via contact transmission. Anti-microbial materials such as zinc, copper, silver as well as carbon and chitosan are integrated into the lay-up of composites. The metals donate ions and therefore have germ-killing effects. Carbon and chitosan also feature anti-microbial properties but the driving mechanisms are still under research. However, all materials are available as powers, which can be either be incorporated into epoxy resins as part of a laminate, or in thermoplastics to be 3D printed. Alternatively, nano-scopic films of these materials can be coated on the surfaces to reduce mass, costs and improve efficiency. Additionally, electrothermal heating systems are also integrated to neutralize biofilms actively. To test the anti-microbial effect intensive contact killing tests are carried out. The aim is to find a highly effective, cheap, lightweight and durable material combination which can easily be applied on surfaces as a retrofit to reduce the risk of contact infection within an aircraft cabin.

Self-assembly of carbohydrate block copolymers: from glyconanoparticles to thin films

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Abstract:
To date, numerous studies have been focused on the self-assembly of petroleum-based BCPs for potential applications in multidisciplinary fields, such as nanoparticles for drug delivery, or nano-organized films for biosensors, or nanolithography, etc. Such materials are derived from fossil resources that are being rapidly depleted and have negative environmental impacts. In contrast, carbohydrates are abundant, renewable and constitute a sustainable source of materials. This is currently attracting much interest in various sectors and their industrial applications at the nanoscale level will have to expand quickly in response to the transition to a bio-based economy. The self-assembly of carbohydrate BCP systems[1-4] at the nanoscale level via the bottom-up approach, has allowed the conception of nanostructured thin films and nanoparticles (micelles, vesicles,…) whose external shell is made from carbohydrates. We will present recent results on the self-assemblies of carbohydrate-based block copolymer leading to nanoparticles presenting different shapes (spherical, cubic, …), highly nanostructured thin films for nanobioelectronic applications.

Keywords: carbohydrate-based copolymers, self-assembly, nanoparticles, thin films

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Transparent Silver-based Coatings Embedded in Oxide Matrices used for Antibacterial Applications

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Abstract:

In the modern world, the use of electronic devices that are frequently touched has become very common and can contribute to the spread of various pathogens. Both temporary and permanent solutions to prevent proliferation are needed to prevent bacterial and fungal infections. In this study, we investigate the use of very thin layers that contain silver nanoparticles embedded into a dielectric layer, as a permanent solution of antimicrobial thin films. These films are obtained on the surface of self-adhesive transparent polymer covers that can be further used as protection for touchscreen devices. The thin films are obtained by a physical vapor deposition technique, combining High-Power Impulse Magnetron Sputtering (HiPIMS) for the deposition of Ag nanoparticles with Radio Frequency (RF) sputtering for the deposition of transparent oxides. Thin films in the range of ~30 nm thickness, including Ag nanoclusters as active antimicrobial agents and SiO_2 and TiO_2 as dielectric matrices, were obtained and characterized.

The coatings were characterized in terms of elemental and phase composition, texture, structure, topography the coatings, and optical properties. Moreover, the antimicrobial activity of the foils was assessed, using E.coli bacteria at different concentrations. Good transparency in the visible spectral range was proven. Moreover, the functional characteristics of the coatings were tested in terms of responsiveness to touch, when stuck onto a touchscreen device. The presence of nanostructured Ag was demonstrated by spectrophotometric measurements and XRD measurements, indicating the presence of ~10 nm size nano-grains. Comparisons between different film compositions and antibacterial testing methods are also provided.

Acknowledgments: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCCDI – UEFISCDI, project number PN-III-P2-2.1-PED-2019-4966 PED 489, within PNCDI III, and the National Research Development and Inno-vation Plan 2022-2027, Core Program, Project no: PN 23 05, contract no PN11N-03-01-2023, and through Program 1- Development of the National Research-Development system, Subprogram 1.2 - Institutional Performance - Projects to Finance the Excellent RDI, Contract no. 18PFE/30.12.2021.

Keywords: antimicrobial, nanostructured silver, magnetron sputtering

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Novel coatings for alumina nanoporous membranes: investigation of *in vitro* antifouling properties

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Abstract:
Nanoporous membranes (NPMBs), one of the recently investigated local implanted systems, attracted a lot of attention from scientists during the past ten years. This local implant, however, fails due to the fouling phenomenon that occurs throughout the implantation time, which blocks the pores. In this study, electrochemical anodization was used to create alumina NPMBs in two phases. Additionally, ZIF-8 MOF impregnated graphene oxide (GO) free and loaded in a mixture of PVDF/PVP polymer matrix with various ratios were synthesised (see Figure 1) and coated to the created NPMBs using a spin coater. SEM/EDX, TEM, FTIR, XRD, contact angle, and AFM were among the characterization methods used to compare the NPMBs before and after coating. Furthermore, the ions concentration of artificial cerebrospinal fluid (ACSF) and antifouling tests were carried out. Finally, antifouling properties were evaluated against two distinct bacterial species. The synthesised alumina NPMBs exhibited a homogeneous porous structure with pore sizes ranging from 36 to 39nm. The coated layers were found to have microporous coatings on the NPMBs' surfaces. The ions (Al and Zn) emitted by the coated NPMBs were determined to be below the allowable limits. The addition of coating materials significantly reduced the uptake of bovine serum albumin (BSA) in ACSF. Moreover, when compared to pure alumina NPMBs, the antifouling behaviour of the coated NPMBs against the selected strains of bacteria was significantly improved. As a result, it is recommended that current antifouling materials and techniques be used to overcome the limits of inorganic NPMBs implants.

Keywords: Antifouling, ZIF-8 MOF, Alumina NPMBs, graphene oxide, spin coating.

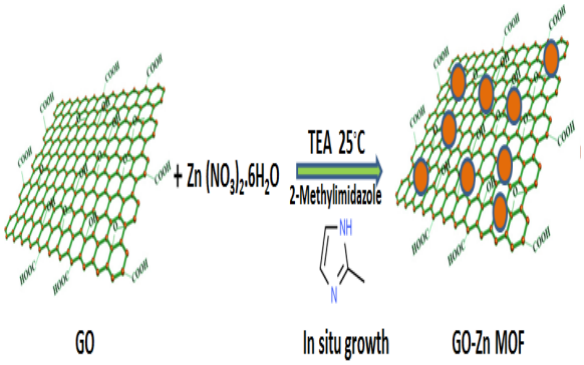

Figure 1: Synthesis procedure of ZIF-8@GO via in-situ growth.

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Electrospun Nanofibers Activated by Amoxicillin Loaded Mesoporous Titania for Bone Regeneration

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Abstract: The repair of bone damaged tissue through tissue engineering requires compiled factors including substrate and growth factors alongside with cells. This research was devoted to fabricate polyvinylidene fluoride (PVDF) based nanofibers for accelerated bone repair without using growth factors. Amoxicillin loaded-mesoporous titania were loaded within the polymer matrix of these nanofibers to enhance their biomineralization and cytotoxicity features. The Microstructure and morphology characterizations of nanofibers were monitored using scanning electron microscopy (SEM). The physicochemical characterization was investigated using X-ray diffractometry (XRD), and infrared spectroscopy (IR). The biomineralization of the nanofibers was assessed in simulated body fluid (SBF). The bone-bonding ability of novel nanofibers was also evaluated. The obtained nanofibers demonstrated promising microstructure(Figure 1), physicochemical features appropriate for enhanced bone regeneration and highlighted the effect of amoxicillin on the cells proliferation and healing rates. Therefore, the utilized nanofibers loaded with amoxicillin are greatly recommended to be utilized as bone healing materials in the absence of growth factors.

Keywords:
Nanofibers; Mesoporous Titania; Amoxicillin ; Bone regeneration.

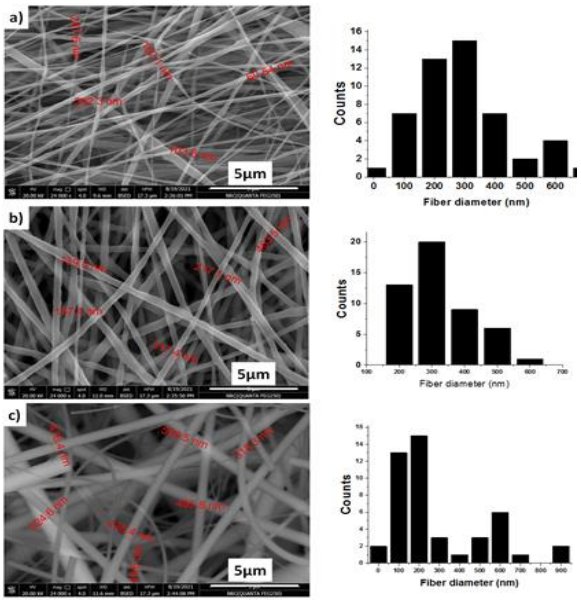

Figure 1: SEM images and fiber size distributions of prepared nanofibrous scaffolds a) PVDF/PCL, b) PVDF/PCL loaded with Ti-free drug, c) PVDF/PCL loaded with Ti-loaded with drug,

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Comparative Neuroprotective Potential of Nanoformulated and Free Resveratrol against Cuprizone-enhanced Neuroinflammation

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Abstract:
Multiple sclerosis (MS) is the most common myelin neurodegenerative pathology. Cuprizone (CZ) is used to induce MS-demyelination experimentally. Oxidative stress and neuroinflammation are the main proposed mechanisms for CZ-induced demyelination. Resveratrol (RESV) is a polyphenolic compound that exhibited neuroprotective activities. Iron oxide nanoparticles (IONPs) were synthesized and characterized by FTIR, TEM (Fig. 1), Zeta potential, and XPS. The in vitro drug release of RESV from Fe_3O_4-NPs was carried out in PBS and determined using fluorescence spectroscopy. This study was conducted to explore the neuroprotective potential of IONP-RESV (10 mg/kg orally for two weeks) and compared it with free RESV in CZ-intoxicated male rats that received 2% CZ-diet only for five weeks. CZ administration triggered oxidative stress manifested as significantly elevated lipid peroxidation associated with significantly declined glutathione reduced (GSH), catalase (CAT), and glutathione peroxidase (GPx) in the brain tissues. Molecularly, CZ resulted in a significant downregulation of myelin proteolipid protein (PLP), along with significant upregulation of S100β, tumor necrosis factor-α (TNF-α) signifying demyelination and neuroinflammation. Treatment of CZ-rats with either RESV or IONP-RESV caused the reversal of oxidative stress variables, upregulation of PLP, and downregulation of S100β and TNF-α. These results were supported by the histological analysis of the cerebral cortices of different groups. Our findings further confirmed the higher anti-inflammatory potential of IONP-RESV than that of free RESV through significant downregulation of S100β and TNF-α. In conclusion, IONP-RESV could represent a better therapeutic candidate than free RESV in mitigating the neuroinflammatory impact of CZ-induced demyelination via anti-oxidative, anti-inflammatory, and remyelinating activities.

Keywords: Cuprizone, Resveratrol, Myelin proteolipid protein (PLP), neuroinflammation, Iron oxide nanoparticles (IONPs), S100β.

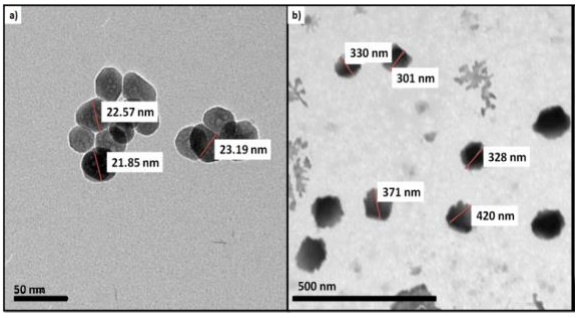

Figure 1: TEM Images of: **a)** Magnetic Fe_3O_4-NPs (IONP), and **b)** IONP-RESV

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Creating and exploring non-reciprocal colloidal microparticles as swimmers

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Abstract:
Most colloidal particles are micrometer-size spheroid, ellipsoidal, cubic or tubular shaped. Nonetheless, colloidal particles with increasing complexity have been developed in the last decades, aiming new functionalities and applications such as self-assembly and autonomous flow for sensors, delivery systems, catalysts or motors. Since microsized swimmers have to break symmetry locally in a well defined way in order to self-propel in a predictable direction, avoiding a pure random walk in an environment dominated by viscosity, using non-reciprocal shapes as building blocks is of great advantage when designing this type of systems. Yet, the pathway from promise to reality is still full of challenges, being the closest ones the development swimmers with adequate morphology for motion and swimmers able to harvest energy from mild sources, avoiding the commonly explored systems such as H_2O_2/metallic catalyst[1,2]. In this work, anisotropic colloidal particles based on polyoxometalates (POMs) with organic moieties are explored as templates for molecular delivery with autonomous movement triggered by changes on environment conditions that cause self degradation of the particles. Different coatings and surface fuctionalization are explored in order to assure particle stability in the "off" condition, and instabilily when "on", in the swimming environment.

Keywords: polyoxometalates, anisotropic particles, colloidal motors, microswimmers, hybrid materials, surface fuctionalization, autonomous movement.

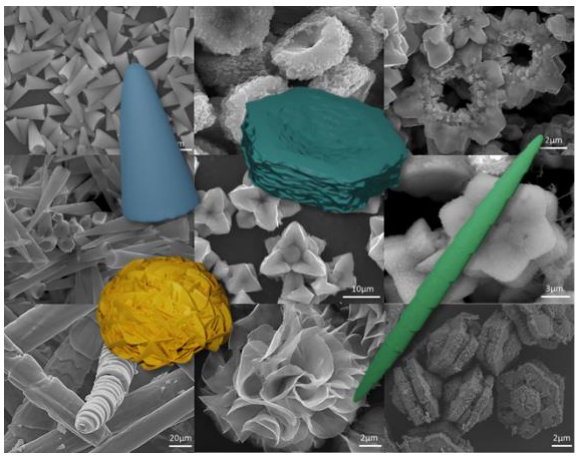

Figure 1: Anisotropic hybrid POM microparticles developed to be explored has swimmers.

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Acknowledgements: E. T. C. Coimbra e Silva is thankful to FCT for the PhD grant SFRH/BD/04841/2020.

EGF 2023 - Session I. C: Graphene and 2D Materials synthesis, characterization, and properties

Bringing atomic precision to the synthesis of graphene-based lateral heterostructures

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Abstract:

Bottom-up nanoarchitectonics has demonstrated the capability to control structural parameters of nanomaterials with atomic precision. The surface-assisted synthesis of graphene-based one-dimensional nanostructures à la carte distinctly illustrates the power of this concept. However, despite impressive advances in the synthesis of 1D homostructures, advancing in structural complexity faces major challenges. A clear example is the extension of the on-surface strategy to two-dimensional structures, where examples of long-range ordered nanoarchitectures are very limited. Recently, we have developed an effective strategy to maximize long-range order in 2D, by synthesizing graphene nanoribbon to use them as 1D building blocks that are laterally coupled in a second step [1].

Here we show how molecular engineering of the coupling bridges enables the extension of this method towards the synthesis of more complex 2D nanoarchitectures.We will show an example where the introduction of phenyl groups in the bridges brings tunability of the quantum electronic coupling and the corresponding in-plane electronic anisotropy [2]. In a second example we extend the method to mix two intercalated components to lead to the formation of lateral heterostructure superlattices where the junction is defined with atomic precision [3].

Keywords: bottom-up synthesis, graphene nanostructures, nanoporous graphene, scanning tunneling microscopy.

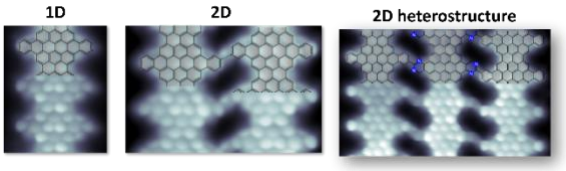

Figure 1: Bond-resolved STM images of a 1D graphene nanoribbon (left); coupled nanoribbons forming the unit of nanoporous graphene (center); a trimer forming the basic unit of a lateral heterostructure superlattice (right) (right).

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Molecular Modelling of Structure and Mobility of Aqueous Electrolytes in Neutral and Charged Graphene Nanochannels

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Abstract:

Understanding the microscopic behaviour of aqueous electrolyte solutions in graphene-based nanochannels with heights comparable to a few molecular diameters is important in nanofluidics applications such as water purification, fuel cells, and molecular sensing. Under such extreme nanoscale confinement (<2 nm), the physical and chemical properties of water and ions differ drastically from those in the bulk phase. In this work, we study the structural and diffusion behaviour of several prototypical aqueous solutions of electrolytes (LiCl, NaCl, and KCl) confined in both neutral and positively-, and negatively-charged graphene nanochannels. We perform molecular dynamics simulations of the solutions in the channels with either 1-, 2- or 3-layer water structures (Fig. 1) using the effectively polarisable force field for graphene [1-3].

The 7Å 1-layer channels have the biggest effect on water structure and adsorption of ions. Only co-ions (ions of opposite charge than the surface) can enter the pore, which applies also to the neutral channel where the ions do not enter due to partial loss of their hydration shells. The 9Å channels feature the highest numbers of water-ion bonds, since the number of water molecules here is still limited, but both counter-ions and co-ions enter them, including the neutral channels. The properties of the 12Å 3-layer channels are closest to the bulk ones.

The hydrogen bonding in the 7Å channels are unique, since only one layer of oxygens is formed in the center of the channel, with a maximum of density exactly at the channel centre or slightly split to a double-peak. This results in diffusivities of water and ions that exceed the values found for other channels and that nearly reach the bulk values or even exceed them, namely water with LiCl. The cations also exceed their bulk diffusivities On the other hand, the positive surface charge promotes in-plane orientation of water molecules allowing big number of H-bonds in the 7Å channel, which is exceeded only by values in pure water systems. The resulting diffusivities of water and ions are subsequently extremely low, only about 10% of bulk water values. The effect of surface charge on composition and dynamics of aqueous solutions in the narrowest channels is exceptionally high, which should be used in the design of microfluidic and separation devices and other applications.

Keywords: adsorption of ions, capacitive deionisation, layer water structure, hydrogen bonding network, self-diffusion coefficient.

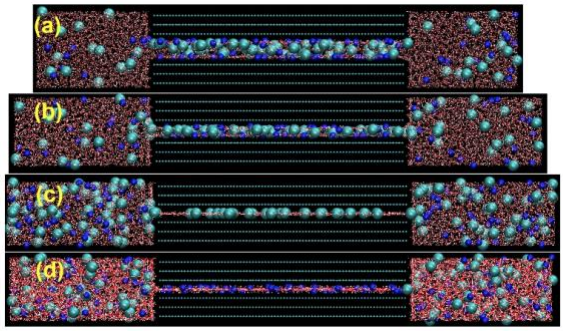

Figure 1: Examples of the simulation box for the bulk reservoir-graphene nanochannel set-up with an aqueous NaCl solution. (a) Neutral channel of the height H =12 Å with a 3-layer water structure, (b) neutral channel of H =9 Å with a 2-layer water structure, (c) positively-charged channel of H=7Å with a 1-layer water structure, and (d) negatively-charged channel of H=7Å with a 1-layer water structure.

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Lateral Growth of Tungsten Disulfide-Graphene Heterostructures using Chemical Vapour Deposition for Large Scale 2D Devices Fabrication

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Abstract:
Graphene is an attractive material for electronic, biosensing, and optoelectronic applications owing to its extremely high mobility, gate-tuneable Fermi level, and broad-spectrum bandwidth. However, the absence of a band gap, and its weak light absorption, in addition to the absence of a gain mechanism, limit their electronic and optoelectronic applications. The co-integration of graphene with other 2D materials has been extensively studied in the last decade to realise high performance and new device functionalities that do not exist in a single material. Graphene-Transition metal dichalcogenides (TMDCs) such as MoS2, WS2, MoSe2, and WSe2 vertical heterostructures have been demonstrated in many electronic and optoelectronic applications due to the wide band gap range and strong light-matter interaction in TMDCs, and the ability to form an electrostatically tuneable junction with graphene. Vertical stacking of the 2D materials can be achieved using mechanical exfoliation. However, the lateral growth of 2D materials at graphene at the graphene interface has been proven to be challenging because of the absence of dangling bonds on both materials, large lattice mismatch, and the lack of selective etching for 2D materials. Here, we demonstrate a process of WS2 growth at the edge of graphene using chemical vapour deposition, where graphene has been first patterned on the substrate, followed by the edge growth of WS2. Using different surface analysis techniques such as atomic force microscope, Raman, and scanning electron microscope, we showed highly crystalline growth of WS2 and atomically sharp graphene-WS2 junction. We further performed current-voltage measurements on the Gr-WS2 heterojunction. The results show good rectifying behaviour and high photoresponsivity. The process is scalable and controllable and can open the door to making a wide range of graphene-heterojunctions that could be the building blocks for many future electronic and optoelectronic devices.

Keywords: 2D materials lateral junctions, large-scale CVD growth 2D materials, Lateral heterostructures.

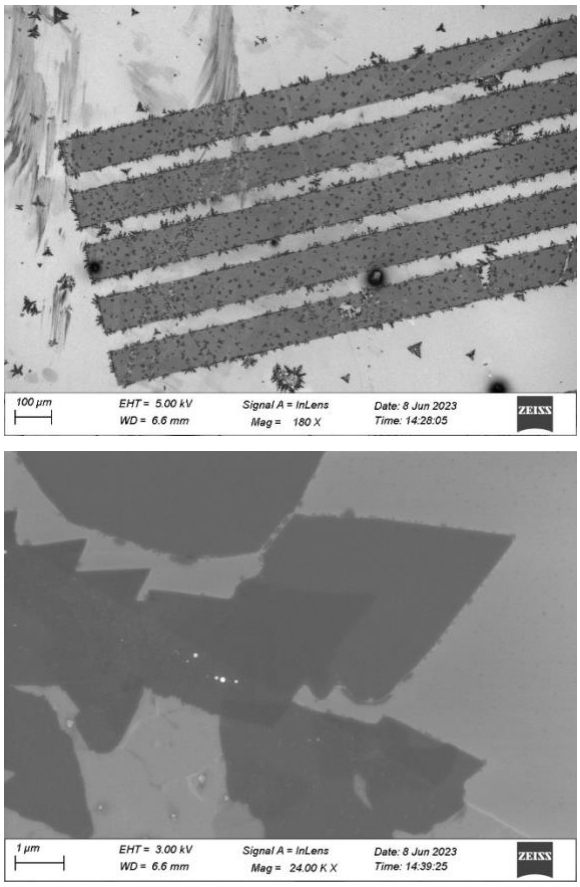

Figure 1: (a) SEM image of graphene stipes and darker WS2 triangles growing at the edges of graphene. (b) Enlarge SEM image of the graphene/WS2 junction.

Growth of III-V Semiconductors on Graphene

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Abstract:
Remote epitaxy and van der Waals growth have attracted a great deal of attention in the past decade as they offer a promising pathway to overcome the challenges in growth of highly mismatched material systems through a 2D interlayer, such as graphene [1].
To date, the growth mechanism of remote epitaxy at the atomic scale is still unclear and has been the subject of controversial studies [1-5]. While some works reported weak interaction between the crystals grown on grapthene with the substrate under graphene by providing DFT calculations supported by experimental evidence [1-4], a recent work has challenged their assumptions and provided experimental evidence supporting a different growth mechanism, i.e. seeded growth on the pinholes formed in graphene (prior to growth) and the consequent lateral overgrowth on graphene [5].
In this talk, we demonstrate growth of III-V semiconductors on graphene monolayers on three different substrates: (1) amorphous silicon dioxide (SiO_2), (2) crystalline germanium (Ge), and (3) semicrystalline germanium native oxide (GeO_x). We show that while mostly polycrystalline polytypic (zinc blende/wurtzite) structures formed on Gr/SiO_2 [6], tens of micron large islands grew on Gr/GeO_x/Ge (Figure 1). While emphasizing the effect of underlying substrate on growth morphology, we further aim to provide more insights on growth mechanism through real-time monitoring of the evolution of surface chemistry and structure by means of LEEM, μLEED, and XPEEM.

Keywords: remote epitaxy, van der Waals growth, III-V semiconductors, highly-mismatched material systems, 2D material, graphene.

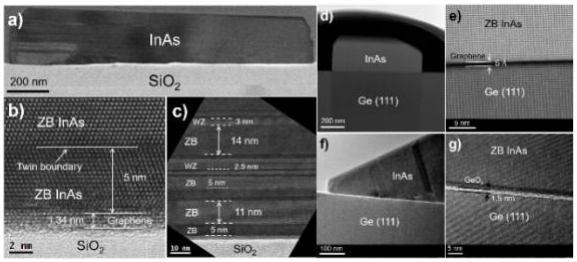

Figure 1: (a) Bright field cross-sectional TEM image of an InAs crystal grown on Gr/SiO_2, (b) high-resolution (HR) images of the crystal in (a) showing a coherent interface, (c) the polytypic nature of the crystal, (d) high-angle annular dark field (HAADF) image of an InAs crystal grown on Gr/Ge, (e) HR-HAADF image of the crystal in (d) showing monolayer graphene at the interface, (f) bright field cross-sectional TEM image of an InAs crystal grown on Gr/GeO_x, (g) HR image of the crystal in (g) showing germanium native oxide at the interface.

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Van der Waals Semiconductors: Exploring the Potential of Oxidation-Induced Heterostructures

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Abstract:
The van der Waals semiconductors family, including GaTe, GaSe, InSe, In_2Se_3, and InTe, has attracted increasing attention due to unique physicochemical properties. Surface science plays a crucial role in determining their potential applications. Surface-science experiments and density functional theory (DFT) have been employed to investigate the oxidation of these materials, driven by vacancies and edge sites created during the exfoliation process. The formation of nanoscale sub-stoichiometric wide-band-gap oxide skin, like Ga_2O_3 and In_2O_3, on these semiconductors significantly impacts their properties and catalytic capabilities [1-3].
The self-assembled metal-oxide/metal-chalcogenide heterostructure formed by the oxide skin and the underlying bulk metal chalcogenide exhibits unique electronic and chemical properties. In particular, the electronic structure of these materials undergoes significant changes upon oxidation, affecting the distribution of charge carriers and modifying the density of states. These changes in the electronic structure result in modified band gaps, enabling the activation of photocatalytic processes with different wavelengths [2, 4].
The presence of metal and chalcogen vacancies has been found to be necessary to decrease the energy barrier for the hydrogen evolution reaction (HER) in acidic media [5, 6]. The oxidation process and the consequent alterations in the electronic structure facilitate the transfer of charge carriers between the layers of the heterostructure, thereby promoting various catalytic processes [2] .
Furthermore, the study of surface science in these materials has revealed their potential for gas sensing applications. The self-assembled metal-oxide/metal-chalcogenide heterostructure enables sensing of NO_2, NH_3, and CO at operational temperatures up to 600°C. This finding highlights the importance of understanding the surface properties and oxidation processes in these layered semiconductors for tailoring their sensing capabilities [2, 4].
In conclusion, the surface science of van der Waals semiconductors, such as GaTe, GaSe, InSe, In_2Se_3, and InTe, plays a crucial role in determining their physicochemical properties and potential applications. The formation of nanoscale sub-stoichiometric wide-band-gap oxide skin and the self-assembled heterostructures profoundly influence their electronic structure and performance in electrocatalysis, photocatalysis, and gas sensing. A deeper understanding of the surface science and the associated changes in electronic properties in these materials can pave the way for new opportunities in the fields of energy, catalysis, and sensing.

Keywords: Van der Waals semiconductors, Oxidation process, Self-assembled heterostructure, Surface science

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Thermal probe of correlated states in bilayer graphene

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Abstract:
Measurement of thermodynamic properties of an electronic system such as thermoelectric power (TEP) can offer a view which is distinct from that offered by other techniques. For example, in the case of a clean non-interacting 2D electron system, it has been shown that TEP is proportional to the transport entropy of the 2D electron system. A similar connection between TEP and entropy was later proved to hold for strongly interacting electrons in high magnetic fields. This makes TEP a powerful tool to reveal statistical properties of fractional quantum Hall (FQH) states as the entropy carried by non-Abelian quasiparticles is predicted to be anomalously larger than that of Abelian quasiparticles. In this talk, I will present magneto TEP studies of bilayer graphene devices which exhibit well-developed FQH states at relatively low magnetic fields. Our data indicates that TEP can be a more sensitive probe of correlated states compared to resistivity measurements. The observed FQH states are being studied further by temperature and magnetic field dependence TEP measurement to probe their toplogical properties.

Keywords: 2D materials, FQHE, Thermopower, bilayer graphene, topology,

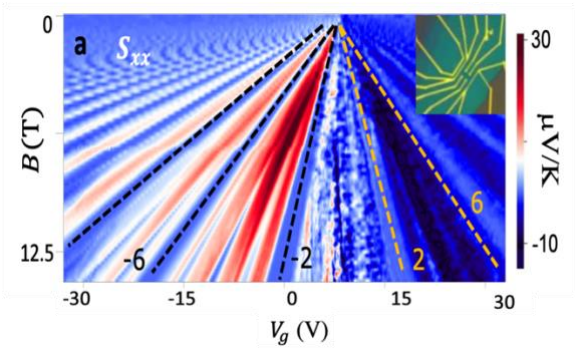

Figure 1: Figure illustrating TEP can be used as a sensitive probe of quantum Hall states in graphene systems. This data shows the Landau fan diagram of longitudinal TEP (S_{XX}) measured for a graphene sample at T = 2 K. Dark blue color corresponds to S_{XX} = 0. The orange and black dashed lines display QHE states at filling factors ν = ±2,±6 for electrons and holes, respectively.

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Graphene functionalization via electrochemical Pd nanoparticles deposition to enhance ammonia sensing

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Abstract:
2D materials show unique physical and chemical properties which can be exploited in several applications, including chemical gas sensors [1]. Among the 2D materials, graphene has attracted particular interest, and it has started to be used as a sensing element to detect and monitor concentration of different gases [2]. Nevertheless, pristine graphene does not always show remarkable performances as gas sensor, and functionalization is often required to improve its sensing capability [2-4].
Ammonia (NH_3) monitoring is quite imortant for several applications, including environmental monitoring, breathomics and food quality tracking. Indeed, NH_3 is one of the precursors of fine particulate, which is a treat for human health, and it is considered as the biomarker of liver and kidney failure [4]. Finally, spoiled food, could release small quantities of NH_3 (order of magnitude low ppm-ppb) [4].
In the present study a set of four samples prepared by transferring graphene on silicon nitride substrates have been successfully decorated with palladium nanoparticles (Pd NPs) via electrochememistry. In details, four samples have been prepared through chronoamperometry deposition of Pd NPs and different particle sizes and densities have been obtained by tuning both the pulse potential and the deposition time. Characterization have been perrformed by Raman spectroscopy, which shows that the graphene layer has not been damaged during the deposition process, Atomic Force Microscopy, which reveals the morphology of the samples and the NPs size and coverage, and X-ray Photoemission Spectroscopy, which allows for an accurate quantification of the relative amount of the Pd NPs compared to the graphene contribution and for the disclosure of the chemical bonds. After the characterization, the functionalized samples, along with a pristine graphene layer, have been mounted on a properly designed platform, in order to simultaneously monitor their response to NH_3 as chemiresistive sensors. This allowed us to directly compare the performances of the 5 sensors under the same working condition. Calibration curves for NH_3 exposures have been drawn for each sensor, quick recovery of the functionalized graphene layers have been observed, detection limit has been evaluated and a sensitivity investigation reveals that the functionalization improves the sensing capability of graphene. Moreover, a trend in the increase of sensitivity towards NH_3 with the increase of the Pd concentration in the functionalized samples has been observed. To give an example, for a 10 ppm NH_3 exposure, the sensitivity of the functionalized layers has been found to be enhanced by 80% (sample with the lowest Pd concentration) up to 92% (sample with highest Pd concentration) compared to the pristine layer. Finally, selectivity has been proven testing the sensors towards acetone, ethanol, 2-propanol, and nitrogen dioxide.
These results open the possibility to a real application of the sensors in environmental monitoring, food quality tracking or medical screening campaigns.

Keywords: gas sensors; graphene; palladium nanoparticles; graphene functionalization; ammonia.

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Molecularly imprinted sensors for electrochemical analysis of pharmaceuticals in environmental waters

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Abstract:

Over the years, fresh water sources have been intensively used and altered by contaminants of various categories. Among them, pharmaceuticals have attracted a special attention, since several studies have proven their presence in different water bodies across the globe, including Wastewater Treatment Plants (WWTPs) effluents and influents [1]. As these compounds are designed to interact with specific processes of target molecules, it is consensual that even at low concentrations, pharmaceuticals can produce undesirable effects on non-target organisms enhanced by chronic exposure and mixture of several compounds [2]. Therefore, the development of specific, simple, and rapid analytical tools to screen their levels in environmental waters is of paramount importance. Owing to their ability to simplify all analytical procedure, where miniaturization and portability can be easily achieved, electrochemical sensors combined with moleculary imprinted polymers (MIPs), as recognition elements, have shown great potential for environmental target analysis [3]. Accordingly, electrochemical devices based on MIPs were developed for the detection and quantification of azithromycin, amitriptyline, atorvastatin and citalopram. The sensors were constructed based on the modification of screen printed carbon electrodes (SPE) surface. Computational studies were employed to study the pre-polymerization conditions and to better understand key interactions responsible for imprinting effect. Using different voltammetric techniques, the developed sensors exhibited good analytical performances and high selectivity to recognize the target. Additionally, they were successfully applied in spiked water samples, thus demonstrating their potential as a useful and sustainable strategy for monitorization of pharmaceuticals in environmental waters.

Keywords: bio-inspired sensors, analytical nanotechnology, computational simulation, green chemistry, environmental analysis.

Acknowledgments:

P.Rebelo (SFRH/BD/132384/2017) and J.G.Pacheco (SFRH/BPD/101419/2014) are grateful to Fundação para a Ciência e a Tecnologia (FCT) and European Union (EU) for their grants,financed by POPH-QREN-Tipologia 4.1-Formação Avançada, funded by Fundo Social Europeu (FSE) and Ministério da Ciência, Tecnologia e Ensino Superior (MCTES).

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Advancing Chemical Sensors through Novel Architectures Based on Functional Hybrid Nanofibers

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Abstract:
The demand for sensors and biosensors that offer simplicity, real-time functionality, and effectiveness in clinical diagnosis, food analysis, and environmental monitoring is steadily increasing. To meet this demand, it is crucial to develop sensors that exhibit enhanced performance metrics in terms of sensitivity, limit of detection, and reliability. Recent advancements in electrospun nanofiber engineering have demonstrated promising results in enhancing the performance of sensors and biosensor devices. These nanoscale structures provide several advantages, including a high surface-to-volume ratio, interconnected porous structure, easy diffusion, and adjustable surface functionality. Additionally, nanofibers have proven to be effective platforms for immobilizing biomolecules and other inorganic (0D, 1D and 2D) functional nanomaterials, resulting in improved sensor performance. In this presentation, we will showcase various strategies (such as adsorption, covalent binding, etc.) recently employed by our research group [1-8] to immobilize inorganic nanoparticles, two-dimensional materials, and functional receptors onto nanofiber surfaces. These strategies facilitate the development of diverse chemical sensors, including electrochemical and chemiresistive sensors, electronic tongues, and electronic noses, applicable across a wide range of fields [1-8]. Specifically, we will discuss their applications in food analysis (e.g., evaluation of food spoilage, detection of mycotoxins), environmental monitoring (e.g., detection of heavy metals, pesticides), and healthcare, providing relevant examples during the presentation. Lastly, we will address the current challenges and future prospects in the design of nanofiber-based sensors and biosensors, shedding light on the exciting possibilities that lie ahead.

Kewords: chemical sensors, optical sensors, solution blow spinning, graphene, surface modification, limit of detection.

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Terahertz Array Beamforming Using Low-Voltage Graphene-Modulators

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Abstract:
The terahertz band (0.1-10 THz) is a vastly unused segment of the spectrum, set to be used by future 6G communications, for its super high transmission speeds. Not only that, but radiation in the below infra-red band is also finding more uses in various applications, such as sensing and medical, where THz may enable innovative solutions. However, technology for this part of the spectrum is still in its infant stages of development. From emitters, to receivers, signal generators, antennas, the devices aren't yet matured or even realized. In this work we present a 4x2 antenna array, whose diagram is controlled via graphene modulators, designed having in mind a fabrication process available for 8 inch wafers. Chemical potentials of 0.1 to 0.4 eV are used, which corresponds to maximum bias tensions of 5 V, that should be more easily implemented with conventional electronics. This allows a comprehensive diagram control, reaching 360 degrees of reach in Phi, and at least 15 degrees in theta (Figure 1). Theoretically, a plasmonic array with graphene modulators could use graphene radiators to achieve incredible size reduction. In practice, graphene will not have enough efficiency to serve as a useful radiator, and metallic radiators should serve as the main emitting elements (Figure 2). This means a compromise between array dimensions and radiation efficiency, as the metallic elements do not support plasmonic transmission at the 1 THz frequency. Additionally, graphene on-chip electronics implementation in the micro and nanometer range presents several challenges. Adding additional graphene elements besides the modulators may also not be feasible with current available fabrication processes and measuring capabilities, or in functional sense.
Some planned-for-fabrication devices are presented. Their architecture was designed to facilitate measurements in probe-less THz measurement ranges. The fabrication masks are ready, and the devices should be relatively simple to fabricate.
Keywords: antenna arrays, beamforming, graphene, nano-devices, THz measurements

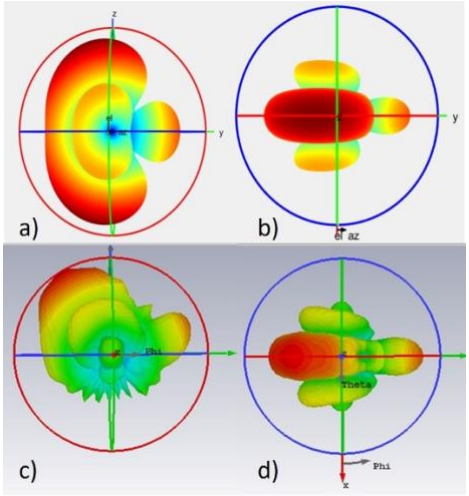

Figure 1: Array factor designed to point at Phi = 270 and Theta = 15, and the simulated results. A) and b) represent the array factor, while c) and d) are the corresponding simulated radiation diagrams.

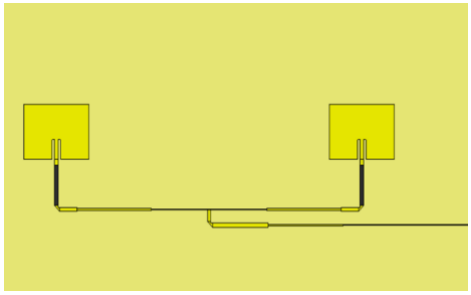

Figure 2: Possible array configuration, showing a feeding network, graphene modulators, and gold patches.

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EGF 2023 / SMS 2023 Session II. A: Graphene properties and applications
Functional / Multifunctional, Hybrid, Composites and Responsive Materials

Understanding thermal transport in Transition Metal Dichalcogenides: from the monolayer to the bulk

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Abstract:
Layered Transition Metal Dichalcogenides (TMDs) have received significant attention in the past years because of their exceptional properties, which differ from those of 3D-bonded materials. Reaching an understanding of their thermal properties is crucial for many applications e.g., in electronics and thermoelectrics. We present a theoretical study of the phonon heat transport properties of WS2, WSe2, MoS2 and MoSe2, from the monolayer to the bulk. We calculate the thermal conductivity of TMDs by solving the Boltzmann Transport Equation for phonons, using input from first principles calculations. We use the SIESTA method [1], based on Density Functional Theory, to compute ab-initio energies and forces from which we obtain the phonon structure and the phonon-phonon interactions using the Temperature Dependent Effective Potential package for finite temperature lattice dynamics calculations [2]. We compute the thermal properties for the TMDs at room temperature and compare the results with experiments on a full range of thicknesses, which demonstrates the reliability and efficiency of our computational method [3]. We compare the results for different TMDs and reach a unifying picture of heat transport in 2D-bonded semiconductors, which will be useful for future technologies.

Acknowledgements: This work was supported by Grants PID2022-139776NB-C62 and PID2019-111673GB-I00, funded by MCIN/AEI/ 10.13039/501100011033. We also acknowledge support from the EU MaX CoE (Grant No. 101093374), and by the Generalitat de Catalunya (CERCA and Grant 2021SGR00997). We gratefuly acknowledge computing time on Marenostrum IV (BSC) provided by PRACE and by RES Projects FI-2022-2-0042 and FI-2022-3-0033. ICN2 is supported by the Severo Ochoa Centers of Excellence Program from Spanish MINECO under Grant No. CEX2021-001214-S. We acknowledge Prof. Olle Hellman for sharing the TDEP code, and for his collaboration on its use.

Keywords: Transition Metal Dichalcogenides; Thermal Transport; Phonons; Boltzmann Equation; Density Functional Theory; Temperature Dependend Effective Potential.

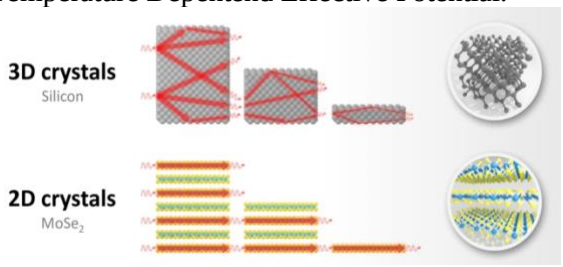

Figure 1: Schematic view of the heat transport mechanism in 3D materials compared to layered materials composed of 2D sheets. In the latter case, thermal conductivity is quite unsensitive to the thickness, as heat is transported within each layer.

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Large-scale production and commercialization of graphene-based solutions for electromagnetic interference shielding applications

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Abstract:
Since 2004, the journey from laboratory-scale synthesis to the sucessful large-scale industrial production and market implementation of graphene has been a substantial and enduring process. Top-down methods, such as liquid-phase exfoliation of bulk graphite, are recognised as the most suitable and cost-effective techniques for practical implementation. Graphenest developed an innovative technology to produce graphene through aliquid-phase exfoliation methodology using ultrasonic cavitation assisted by high-shear mixingand is focused on developing and providing innovative conductive materials with extended applications, such as electromagnetic interference (EMI) shielding materials.
EMI is considered a potential and major source of operational problems for electronic devices, as well as a cause of reduced performance and lifetime, especially in a world where electronic devices are becoming increasingly ubiquitous. Current shielding materials used to protect electronic devices from EMI are based on dense, brittle and expensive metals, while the major EMI applications have a huge demand for flexible, additive, lightweight, and low-cost materials. This is critical, for instance, in several vehicles industries, from hybrid and electrical cars to aeroplanes, where weight reduction is essential to increase autonomy and reduce carbon footprint. Graphene and its related materials are considered the most promising and effective candidates for effective EMI shielding due to their excellent electrical properties, extremely high specific surface area, and unprecedented strength-to-weight ratio.[1]

Keywords: graphene-based films, conductive inks, coatings, conductive compounds, electrical conductivity, electromagnetic interference shielding

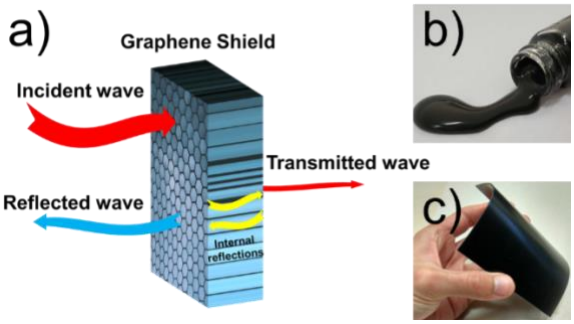

Figure 1: a) The exceptional electric conductivity of graphene renders it an excellent material for EMI shielding, enabling the effective blocking incident electromagnetic waves via reflection and absorption of incoming signals.; b) Graphene-based ink for conductive coatings.; c) Extruded G-Shield slab, a conductive polymeric compound designed for EMI shielding applications.;

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Plastic deformation of B19’ martensite in NiTi shape memory alloy

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Abstract:
Deformation processes responsible for unique thermomechanical loading behavior of NiTi shape memory alloy (SMA) derive from martensitic transformation among B2 cubic austenite to B19’ monoclinic martensite. These processes, involving mainly stress induced martensitic transformations and martensite reorientation, are relatively well understood. On the other hand, mechanism of plastic deformation of B19’ monoclinic martensite, although it has been heavily used in engineering practice, has not been yet fully unravelled. Plastic deformation of B19’ monoclinic martensite has long been considered as being simply due to the activation of dislocation slip and deformation twinning in martensite without understanding them in sufficient detail.

We have investigated plastic deformation of nanocrystalline NiTi wire in tensile test by analyzing: i) martensite variant microstructures evolving in grains of NiTi SME wire deformed in tension by post mortem TEM [1] and HRTEM [2] methods, ii) evolution of martensite texture evaluated by in-situ synchrotron x-ray diffraction [3] and iii) continuum mechanics modelling [4].

It was found that plastic deformation of B19’ martensite proceeds via deformation mechanism involving [100]/(001) dislocation slip based kinking and (100) deformation twinning [2,4]. As this deformation mechanism combines twinning and kinking, it has been called ‘kwinking’. Kwinking deformation gives rise to characteristic deformation band microstructures with (20-1) twin like kwink interfaces in grains of deformed wire [1]. Kwink interfaces are not exact martensite twins but display mirror symmetry (001) crystal planes [2]. Kwinking results in characteristic two fiber martensite texture [3] and refinement of austenitic microstructure down to nanoscale. Plastic deformation of the NiTi wire by kwinking may proceed in homogeneous or localized manner at very high stress (~1 GPa) up to very large plastic strains ~50% at fracture.

Keywords: shape memory alloy, martensitic transformation, NiTi, plastic deformation, TEM analysis of martensite variant microstructure, evolution of texture in martensite, plastic deformation

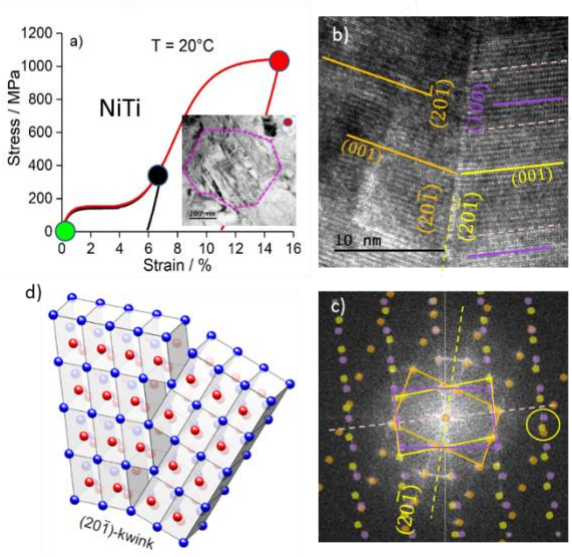

Figure 1: Monoclinic B19’ martensite in NiTi shape memory alloy deforms via kwinking deformation mechanisms combining [100](001) dislocation slip based kinking with (100) twining. a) stress-strain curve from tensile test at room temperature on nanocrystalline NiTi wire in martensite state. HRTEM image (b) and FFT pattern (c) from (20-1) kwink interface and its atomic model (d).

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Overcoming the adhesion paradox and switchability conflict on rough surfaces with shape memory polymers

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Abstract

Animals such as geckos can climb vertical walls or even move about upside down on ceilings. Such locomotion requires strong and ubiquitous adhesion between their feet and various surfaces, yet easy detachment when needed. However, current smart adhesives made of elastomers suffer from the long-standing challenges of the *adhesion paradox* (rapid decrease in adhesion strength on rough surfaces despite strong molecular level interactions) and the *switchability conflict* (trade-off between adhesion strength and easy detachment). Here, we report a new method that overcomes the adhesion paradox and switchability conflict on rough surfaces [1]. Utilizing the rubber-glass phase transition in SMPs, we demonstrate, through mechanical testing and mechanics modeling, that the conformal contact in the rubbery state followed by the shape-locking effect in the glassy state results in the so-called R2G (rubber-to-glass) adhesion with extraordinary adhesion strength (> 1 MPa) on rough surfaces, overcoming the classic adhesion paradox (see Fig.1). Furthermore, upon transitioning back to the rubbery state, the shape-memory effect of SMPs enables easy detachment, leading to improvement in adhesion switchability (up to 10^3, defined as the ratio of the SMP R2G adhesion to its rubbery-state detachment) as the surface roughness increases. The working principle and the mechanics model of R2G adhesion [1,2] provide guidelines for developing stronger and more switchable adhesives adaptable to rough surfaces, thereby enhancing the capabilities of smart adhesives, and impacting various fields such as adhesive grippers and climbing robots.

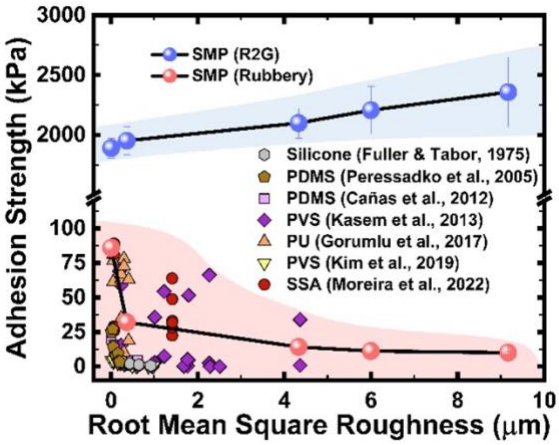

Fig. 1 Adhesion strength of SMP-based smart adhesives under R2G condition for a range of surface roughness, and comparison with other adhesive materials.

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Mechanics of Shape-Locking-Governed R2G Adhesion with Shape Memory Polymers

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Abstract
Shape memory polymers (SMPs), with unique properties such as tunable elastic modulus, temporary shape-locking, and shape-recovery upon external stimulations, are emerging as a new class of smart materials with switchable adhesion capabilities. A prominent feature of the adhesion between SMP and a spherical indenter is the so-called R2G adhesion, defined as making contact in the rubbery state to a certain indentation depth followed by detachment in the glassy state. While it has been demonstrated that the R2G adhesion with SMPs can achieve orders of magnitude higher adhesive strength compared to conventional elastic adhesive systems, the fundamental mechanics of R2G adhesion and why it leads to such tremendous adhesion enhancement remain poorly understood. Here [1], combined experimental testing, theoretical analysis, and finite element analysis (FEA) based on a thermomechanical constitutive model of the SMP are carried out to investigate the mechanics of R2G adhesion with a rigid spherical indenter. The study shows that the orders of magnitude enhancement of R2G adhesion over conventional elastic adhesion systems is governed by the shape locking effect during the transition from the rubbery to glassy states. The shape locking effect freezes the deformed configuration of the SMP substrate, resulting in nearly conformal contact between the spherical indenter and the glassy-state SMP substrate, thus greatly increasing the effective radius of curvature of the contact surface. Our experimental measurements and FEA analysis demonstrate that the net effect of shape locking leads to a pull-off force of a sphere nearly the same as that of a flat punch on an elastic half-space with the same contact radius. An explicit expression of the pull-off force for R2G adhesion is proposed based on flat-punch adhesion. Our results from the combined experimentation, modelling and simulations reveal the fundamental mechanics of R2G adhesion. Such understanding provides guidance for the design of SMP smart adhesives.

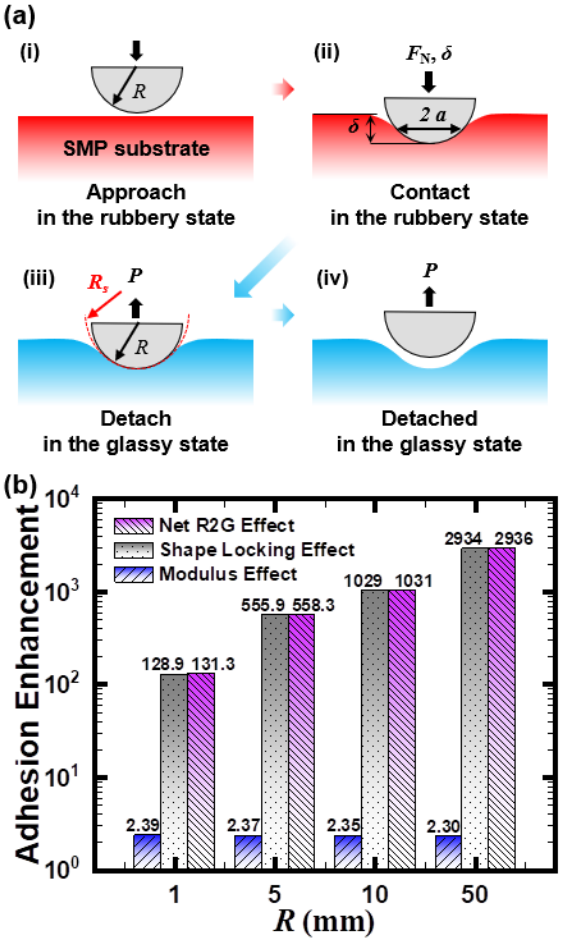

Fig. 1. R2G adhesion between a spherical indenter and the SMP adhesive substrate.

Reference:

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Thermal response of double network hydrogels

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Abstract:
Stimuli-responsive polymer hydrogels offer a wide range of possibilities for advanced applications since the physicochemical and mechanical properties can be controlled by the change of various external parameters, such as temperature, pH, ionic strength and electrical field. Temperature, in particular, is extensively studied as a stimulus in the field of "smart" polymers. Most temperature-sensitive hydrogels exhibit a volume phase transition temperature (VPTT). Below this temperature, the hydrogels swell due to strong hydrogen bonding with water molecules. However, as the temperature rises above the VPTT, hydrophobic interactions between the polymer chains become dominant, causing the hydrogels to undergo a phase transition. As a result, the hydrogels collapse and release water molecules from their interior. The conventional hydrogels are limited in their mechanical properties, which restrict their usefulness in various applications. The methodology of double network (DN) hydrogels [1] has shown the effective improvement of mechanical strength and excellent fracture toughness. Double network hydrogels are a specific type of interpenetrating network hydrogels, composed of two networks with contrasting properties.
The synthesis and characterization DN hydrogels based on various components such as poly(*N, N'*-diethylacrylamide) (PDEAAm) and polyacrylamide (PAAm) will be discussed. Our investigation shows that the DN structure in hydrogels significantly increases the Young modulus. We will also explore the thermo-responsive behavior of PDEAAm/PAAm and PDEAAm/PDEAAm DN hydrogels, as well as the dependence of transition parameters from deswelling, NMR spectroscopy, and DSC experiments on the composition of DN hydrogels. To describe the phase transition of the hydrogels, a two-state process model was employed. By applying a modified van't Hoff equation to the data obtained from deswelling, NMR, and DSC experiments, it was possible to obtain thermodynamic parameters related to the transition (Figure 1). Additionally, the size of the cooperative domains consisting of polymer units and water molecules within the hydrogels could be determined using this approach.

Keywords: thermoresponsive hydrogel, double network, poly(*N, N'*-diethylacrylamide), differential scanning calorimetry, NMR spectroscopy.

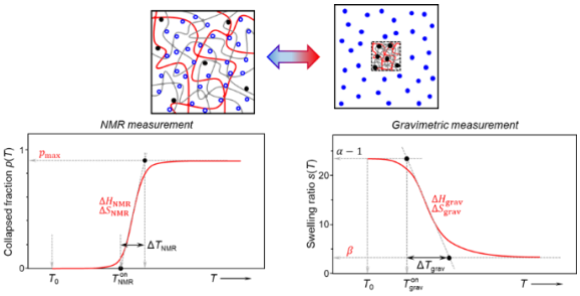

Figure 1: Schematic two-state (swollen-collapsed) model of the temperature-dependent deswelling process of DN hydrogels.

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Influence of the addition of antimicrobial low molecular weight chitosan on the thermal and rheological properties of polybutadiene succinate composites

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Abstract:
Packaging contributes to considerable part of municipal solid waste. Besides it major part of packaging still is made from fossil plastics. To make plastic packaging more sustainable biobased content in it should be increased. Presently, various biobased polymers are offered for replacement of traditional fossil plastics like PE, PP and PET. Some of the most well-known examples are thermoplastic starch, PLA and polybutulene succinate (PBS) based systems. However, these materials, suffer from brittleness, difficult procesability and moisture sensitivity, respectively. This reduces suitability of these biobased polymers for packaging of food. The problem could be tackled by developing multi-functional hybrid systems with high renewables content. Hence, main aim of the authors' team is to develop PBS polymers' based hybrid systems with organically modified layered silicates for improvement of barrier properties and chitosan for endowing antimicrobial characteristics. Melt processability of such systems is usually limited by thermal stability of the organic constituents of the system. Therefore, in this particular research attention is devoted to the influence of low-molecular chitosan (LMWC) on the thermal and rheological properties of two types of PBS polymers with different maximum melting peak temperatures around 90ºC and 118ºC.
LMWC was introduced within both PBS polymers matrices by means of melt compounding. Rheological properties of the both PBS based composites were investigated within the temperature interval of 90-160ºC. In addition, structural and thermal properties were investigated by means of FTIR, DSC and TGA.
In general, it was demonstrated that both LMWC modified PBS systems may be processed by melt compounding in an oxidative environment at temperatures up to 170ºC without considerable destruction of the material.

Keywords: biobased polymer, chitosan, melt compounding, composite, rheological properties.

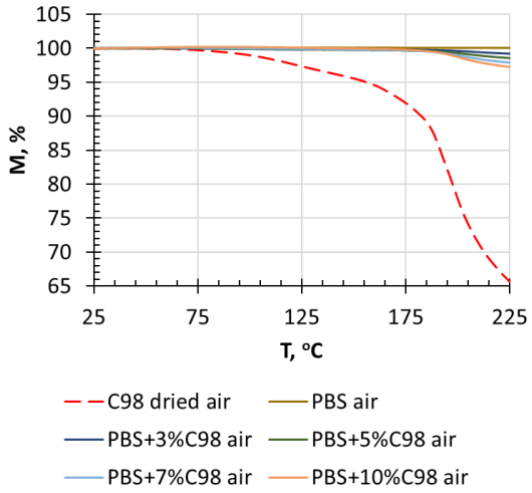

Figure 1: Figure demonstrates no considerable changes in thermogravimetric M(T) relationships of PBS composites with various concentrations of LMWC (C98) up to 170ºC.

Acknowledgement: This research is funded by the Latvian Council of Science, project "Smart Materials, Photonics, Technologies and Engineering Ecosystem" project No VPP-EM-FOTONIKA-2022/1-0001

Ceria-Based Nanocomposites for Catalysis by Magnetic Heating

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Abstract:
Conversion of (renewable) electricity into fuels and chemicals, i.e., the electrification of chemical industry, is one of the keys for decarbonising the planet. Catalysis by magnetic (also referred to as induction) heating is an emerging technology, which enables the efficient use of electricity to supply the heat for thermo-catalytic processes. The technology is based on heating of magnetic nanoparticles imbedded in a catalyst support in an alternative magnetic field. The selective heating of catalyst surfaces can improve the selectivity and yields of catalytic reactions.[1,2] In addition, the technology is very flexible (very fast heating and cooling rates) and brings high hopes for improving energy efficiency.
In this study, magnetic ceria-based catalysts were synthesized. First, magnetic iron-oxide nanoparticles were coated with nanocrystalline ceria using controlled precipitation of the Ce^{3+} ions in the presence of hexamethylenetetramin (HMTA) in the aqueous suspension. In the next step, Ru catalytic nanoparticles were deposited onto the magnetic ceria support (Figure 1). A special attention was given to reveal chemical mechanisms enabling the deposition of homogeneous ceria coatings with a high surface area. Morpho-structural properties of the synthesized materials were characterized using a combination of electron microscopy (SEM, TEM, and aberration-corrected STEM), measurements of specific surface area (BET) and XRD. The efficiency of magnetic heating was evaluated as a function of the amplitude of magnetic field and the structure and magnetic properties of catalyst (measured with VSM). Finally, the magnetic catalysts were tested for relevant chemical conversions where the magnetic heating was compared with the conventional heating.

Keywords: catalysis with magnetic heating, induction heating, magnetic nanoparticles, magnetic catalyst, ceria, nanocomposite, controlled precipitation.

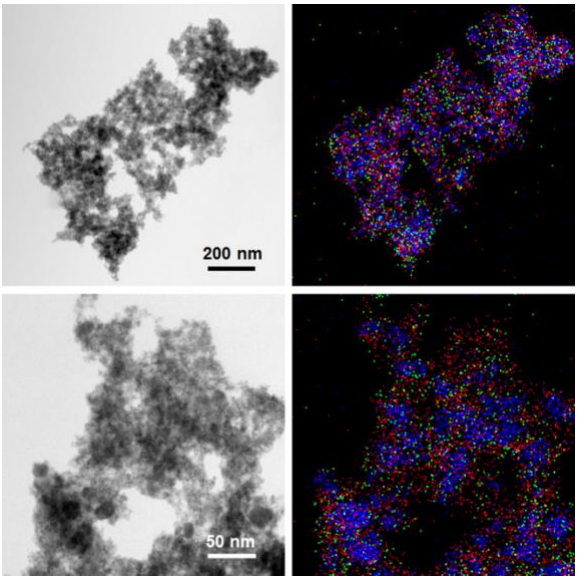

Figure 1: BF STEM images of magnetic ceria-supported Ru catalyst with corresponding EDXS elemental maps showing distribution of Ce (red), Fe (blue), and Ru (green) in the nanocomposite.

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SMS 2023 / Sensors 2023 Session II. B: New Materials for sensors and actuators: Sensing the Future with New Materials

Tactile Perception of Virtual Surfaces generated by Piezoelectric Actuators

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Abstract:
During tactile exploration, the finger perceives vibrations and deformations caused by the friction between the skin and the physical characteristics of the surface. Frequency and intensity of the vibratory stimuli activate mechanoreceptors, which generate a transducted signal giving spatial information on the surface [2,3] and producing a sensory reaction [4].
The aim of the paper is to simulate the tactile exploration of virtual surfaces, and to monitor the sensory reactions, by generating vibratory stimuli with piezoelectric actuators. The virtual touch experimental setup is depicted in figure 1. Piezoelectric actuators oscillate vertically in phase ac-cording to a sinusoidal tension signal. Frequen-cies vary from 5Hz to 45Hz with 5Hz steps, and, for each frequency, the signal amplitude is calibrated from 5µm to 25µm with 2.5µm steps.
A panel of participants has been recruited for a tactile perception experiment. Each panellist was asked to position himself comfortably, with a minimal tension in his arm while applying a weak force to the device by the finger of its dominant hand. Then, the signal was generated, and for each frequency the amplitude was progressively decreased until the participant indicates that he no longer feels the vibration. Thus, for each participant, a frequency-amplitude matrix was filled with zeros when the signal is not felt and ones when it is felt.
Figure 2 gives the percentage of panellists feeling the signal, as a function of its frequency and its amplitude. The vibration is felt by 100% of the panellists for high frequencies and large amplitudes. This percentage decreases when either the frequency or the amplitude is decreased. However, a local increase is observed for large amplitudes when frequencies are around 10Hz. This 10Hz frequency is commonly used as the reference frequency for particular tactile mechanoreceptors.
The use of piezoelectric actuators to simulate actual surfaces is a promising way to develop a prototype of virtual touch. Better spatial resolution and larger signal amplitudes are developed, and model surfaces are manufactured to calibrate the system.

Keywords: Haptic, Virtual, Perception, Actuators, Piezoelectric

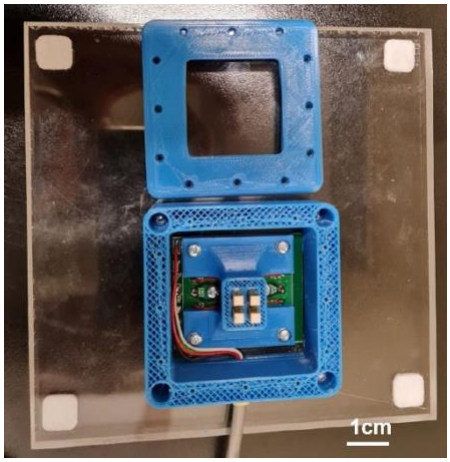

Figure 1: Experimental setup

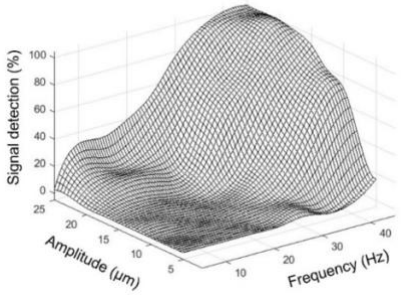

Figure 2: Answering surface of the experiment

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Metallic nanoparticles-based nanomaterial as a non-enzymatic sensor

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Abstract:
One of the most popular ways to test glucose is with electrochemical sensors, which are instruments that capture physical, chemical, or biological changes in a substance and translate them into quantifiable output signals. In comparison to sensors based on alternative detecting processes, they have much lower prices, higher reliability, quick reaction times, and low detection limits [1]. This type of electrode is adjusted using a previously properly developed and obtained material to improve selectivity and satisfy the needs of analysis. Electrochemical measurements are utilized to get the required electrochemical signals when the target analyte were successfully identified on the electrode surface [2].
Non-enzymatic sensors are devices that measure the analyte in the sample without the use of enzymes. The most commonly used materials as the receptor layer include: metals, alloys, carbon-based materials or metal oxide [3]. Non-enzymatic sensors typically rely on analyte characteristics and oxidation-reduction behaviour. The electrical conductivity, capacitance, or their interaction with particular particles or nanoparticles can all be modulated thanks to this capability [4].
Herein, non-enzymatic glucose sensors were obtained based on the hybrid material poly(caffeic acid)@multi-walled carbon nanotubes and copper(ii) oxide and nickel(II) hydroxide. The proposed PCA@MWCNT-CuO and PCA@MWCNT-$Ni(OH)_2$ were used to modify the glassy carbon electrode (GC), thus creating an electrochemical setup.
The proposed systems were used for tests against increasing glucose concentration using amperometry and cyclic voltammetry.
The properties of the proposed sensors were compared in terms of their sensitivity, linearity range and detection limit (LOD).
In addition, an important stage of the research was to check their selectivity, due to the lack of a selective receptor, such as the enzyme.
The non-enzyme systems were also tested for stability over time showing stability for 3 months and 5 months for PCA@MWCNT-CuO and PCA@MWCNT-$Ni(OH)_2$, respectively. Finally, tests were carried out on real glucose solutions, i.e. blood and plasma, in order to test the application system.

Acknowledgments:
The work was financed and prepared by the Poznan University of Technology research grant no. 0912/SBAD/2306. Dr. Artur Jędrzak is also grateful to the Foundation for Polish Science (FNP) for its support through a START scholarship

Keywords: non-enzymatic sensors, glucose detection, copper(II) oxide, nickel(II) hydroxide

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Novel Gas Phase Route Towards Patterned Deposition of Pt/Al reactive multilayers

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Abstract:
Reactive Pt/Al bimetallic multilayers (nanofoils) have ability to release stored chemical energy on local ignition and form stable/metastable alloys. This characteristic finds applications in functional device fabrication, joining metals, preparation of coatings and initiation of secondary reactions. Different from conventional fabrication methods (e.g., physical vapor deposition), this work reports the discovery and advantages of synthesizing nanoparticulate reactive systems instead of sputtered thin film reactive systems using atmospheric pressure gas phase electrodeposition, a bottom-up process (Cole, 2010).

Spark discharge of metal electrodes (Pt or Al) produces sub-10-nm positively charged nanoparticles through cathode erosion which are selectively deposited on an electrically biased silicon substrate with linearly patterned silicon oxide mask (cf. Figure 1A). Directed assembly of densely packed nanoparticulate thin films is material efficient, while being synthesized at room temperature and pressure. No additional lift off is required for this process. On ignition, such multilayers undergo an exothermic alloy formation reaction and release energy. Nanoparticulate thin films with dendritic morphology as shown through TEM/SEM micrographs in Figure 1 B, C provide increased contact points/grain boundaries between the two metals at interfacial regions. The diffused interface accounts for ~ 25% of the deposited layer (Figure 1 D, E) aids in alloy formation on external stimulus. Post ignition, a self-propagating reaction wavefront can be observed using high speed videography at 5000 frames per second. In Figure 1F, we capture the wave front at different time instants to highlight this propagation. Propagation speed was computed to be 10 mm/s. Differential calorimetry studies find that such nanoparticulate multilayers release much larger energy (a factor of 3) as compared to their sputtered counterparts. Predominantly formed alloy includes cubic $PtAl_2$, which was indexed using XRD technique.

While this method shows the discovery and advantages of nanoparticulate Pt/Al multilayers, several challenges exist. The effects of nanoparticle size, ignition temperatures on reaction kinetics and heat release will be the topic of research in the future. The results of this study can further the development of such localized deposition processes to be used as an alternative material-efficient route towards production of reactive nanostructures and systems.

Keywords: functional nanomaterials, calorimetry, alloy, spark discharge, nanopatterning, nanocomposites, energy conversion and storage

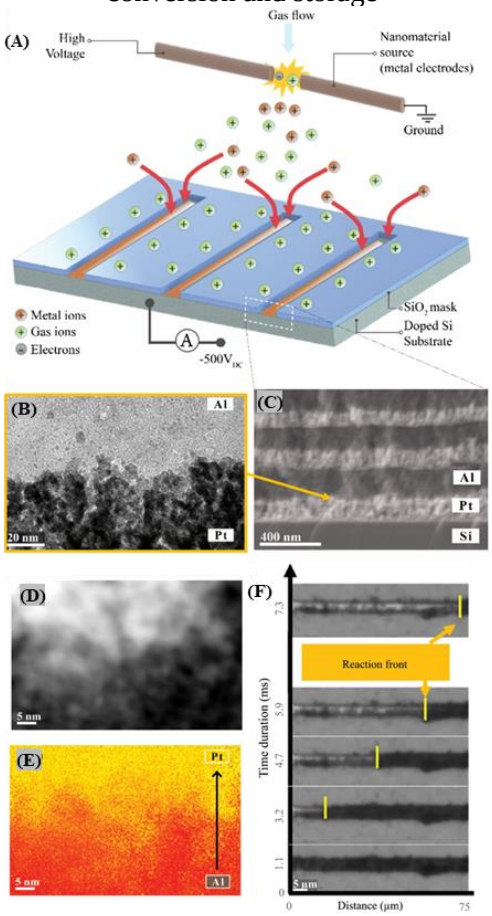

Figure 1: (A) Schematics of gas phase electrodeposition, (B, C) TEM/SEM micrographs, (D, E) EDX studies on a scale of 5 nm; and (F) high speed videography of self-propagating reaction wavefront on ignition.

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Transparent thin films for use as position sensitive photodetector

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Abstract:
Recently transparent and conductive transparent metal oxide films are receiving more attention because of their properties such as light-emitting semiconductivity, possessing high value of exciton binding energy, etc. Due to these properties the films have been used in varities of applications such as high temperature thermoelectric device fabrication, active emitter in LED and laser diodes, TFT for real-time sensing of gas molecules, acoustic sensors, etc.
Being at the beginning of our investigation, our main task consists of obtaining thin films of ZnO using $Zn(CH_3COO)_2 \cdot 2H_2O$ undoped and doped with different additives. The thin films were deposited on glass and silicon substrates by spray pyrolysis technique. The specific amount of dopant (Na, In (NaOH, $InCl_3$)) influences the conductivity, the transparency and the electrical resistivity of the films.
The microstructure and morphology were studied by XRD, SEM and AFM techniques. Spectrophotometer UV-VIS in the region of 300-1800 nm was used to study the transmission spectra of the films. Si-SiO_2-ZnO:Na structures were prepared and the lateral photoeffect was investigated. Under nonuniform irradiation with a laser beam, a lateral photovoltage (LPV) appeared, with high sensitivity to the spot position on the plane of the metal oxide film. The LPV depends on the conductivity and optical transmittance of the films. The position characteristic shows good linearity and resolution and could be useful for practical applications.

Keywords: Thin films, Spray pyrolysis, Metal oxides, Position sensitive photodetector.

Acknowledgements : „This study is funded by the European Union-NextGeneration EU, through the National Recovery and Resilience Plan of the Republic of Bulgaria,
project № BG-RRP-2.004-0002,"BiOrgaMCT""

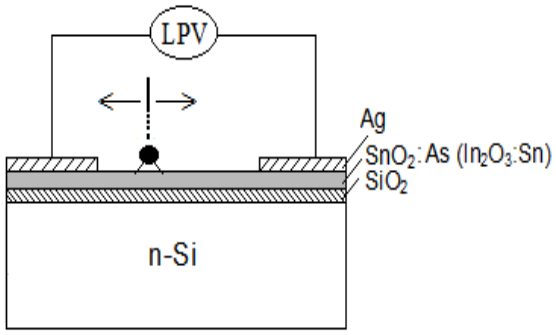

Figure 1: . Schematic view of two dimensional structure Si-SiO_2-ZnO:Na and LPV measurement with variable light spot position.

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Layer by layer method used to investigate correlation between rigidity of matrix and sensitivity of sensors device

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Abstract:
Graphene (G) is one of the most promising 2D material and it becomes central for many research fields organic electronics, sensing and energy storage.[1] However, due to lack of organic moieties which allow supramolecular interactions and reactions of functionalization the graphene oxide (GO) is preferred. Although, implementation of oxygen groups decreases of electrical properties such as: conductivity, capacitance, electron transfer in comparison with pristine graphene.[2, 3] To obtain material which combine electrical properties of G and ability for supramolecular interactions the GO is chemically reduced. According to that the reduced graphene oxide (rGO) is ideal material for working electrical devices application. This research aims at developing new generation of piezoelectric pressure sensors based on two-dimensional materials (non)covalently functionalized with organic molecules and their application in proof-of-concept devices. The study involves the design of a high-efficiency method of graphene oxide (GO) reduction using various reductors, preparation of graphene hybrids material with organic molecules featuring variable rigidity and their processing into thin-films onto flexible surfaces by layer-by-layer method. The schematic ilustration for prepartion of devies is prestened on figure 1. The combination of different rigidity of molecular pillars and conductivity of rGO will allow to investigate impact on responsiveness of piezoelectric sensors.

Keywords: Graphene, reduced graphene oxide, gold nanoparticles, functionalization, layer by layer method, rigidity, sensitivity.

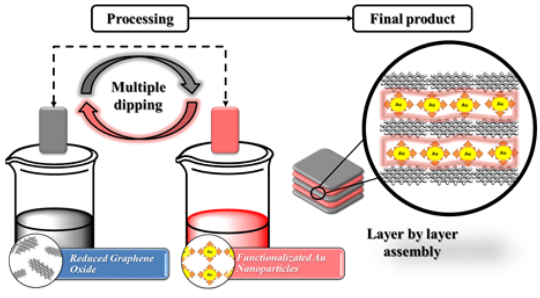

Figure 1: Schematic illustration of layer-by-layer processing.

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Gas sensitivity analysis of the gas-triggered resistive switch - gasistor

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Abstract:

The recently developed device called gasistor[1] has shown the ability to work as a gas-triggered thyristor-like switch and a gas sensor with intrinsic memristive memory, with the ability to store information about reaching the pre-set threshold concentration of hydrogen. The device is formed of a capacitor-like Pt/TiO_2/Pt structure and can be modeled as parallel connection of a chemiresistive gas sensor and a memristor, formed in the same structure. The resistance of the chemiresistive gas sensor decreases with increasing H_2 concentration, while the memristor allows for switching between the high resistance state (HRS) and low resistance state (LRS) and vice versa after reaching the corresponding threshold voltages (V_{set} for switching to the LRS, V_{reset} for switching to the HRS). When biased by a constant current in the HRS, the gasistor responds to decrease of H_2 gas concentration by increasing the applied voltage, eventually reaching the threshold voltage V_{set} and switching to the LRS. The device then stays in the LRS until it is re-set by applying V_{reset} voltage. The information about the H_2 concentration decrease is thus stored in the LRS state.

Due to the parallel connection of the sensor and memristor, the overall sensitivity of the formed device to H_2 gas is limited not only by the sensitivity of the gas sensor, but also by the parallel resistance of the memristor being much lower than the baseline resistance of the sensor. The total resistance of the device in both HRS and LRS thus does not change with increasing H_2 concentration until the resistance of the sensory part becomes comparable to or lower than the resistance of the memristor, as can be seen in Fig. 1. This effectively decreases the sensing limit and sensitivity of the gasistor device. To improve the sensitivity, we need to either increase the resistance of the device in the HRS, or decrease the baseline resistance of the sensor, which seems to be more feasible. This can be reached e.g. by increasing the sensor area by utilizing a large-scale nanoporous top electrode (inset in Fig.1).

Keywords: gasistor, chemiresistive gas sensor, resistive switching, hydrogen

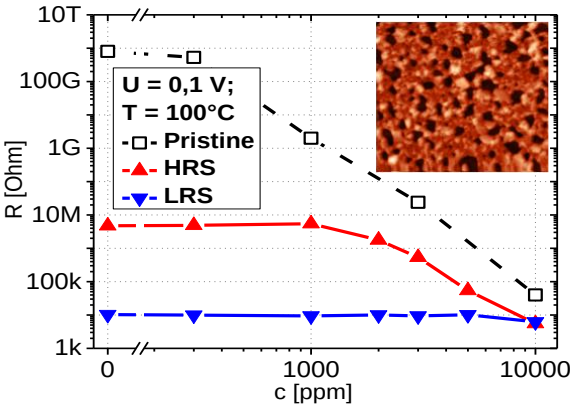

Figure 1: Comparison of resistances of the pristine device (dashed curve) and formed gasistor device with the memristor in the HRS (red curve) and LRS (blue curve) as a function of H_2 concentration in air. The inset shows a 5×5 μm AFM topography image of the proposed nanoporous top electrode.

Acknowledgement:

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-21-0053 and by the Scientific Grant Agency of the Slovak Ministry of Education, Sciences, Research and Sport (Grant No. VEGA 1/0062/22). It is also the result of support under the Operational Program Integrated Infrastructure for the projects: Advancing University Capacity and Competence in Research, Development and Innovation (ACCORD, ITMS2014+: 313021X329) and UpScale of Comenius University Capacities and Competence in Research, Development and Innovation (USCCCORD, ITMS 2014+: 313021BUZ3), co-financed by the European Regional Development Fund.

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Development of optical microsensors based on Surface Plasmon Resonance for gaz measurement in atmosphere

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Abstract:

Although optical transducers are not the predominant devices in the field of sensors dedicated to gas monitoring and are commercialy recent as compared to electrochemical or semiconductor sensors, their potentialities make them attractive. Their high sensitivities, their ability for gas discrimination into a complex gaseous phase, their lowest long-term drift and their easy integration into compact and miniature devices and low-energy consumption devices lead to promising performances. Because they don't require thermal energy for detection, optical sensors are appropriate for explosive gases monitoring, such as H_2, in conformity with the ATEX directive.

This lecture deals with innovative optical sensors based on surface plasmon resonance (SPR) phenomenon implemented on a microstructured grating coated by sensing nanolayers (figure 1). The geometry of the grating (depth, period, profil) is especially designed to benefit from a plasmon-triggered switching effect occurring between the 0^{th} and -1^{st} diffracted orders. This new SPR distributed feedback slow wave exploit The difference of the 0^{th} and -1^{st} diffracted orders intensities, modulated by adsorbed gaseous molecules on the sensing layer allows a much more sensitive, simple and compact sensors. The sensitivity and the selectivity to gas is strongly determined by the sensing nanolayer coated on grating. Experimental results highlight that nanolayer of copper phthalocyanine leads to reducing gases sensitivity (especially towards NO and NH_3) with LOD close to few ppm (figure 2) while nanolayer of palladium gives high responses to hydrogen with LOD close to 0,05% (figure 3). Repeatability, reproducibility, resolution and long-term stability must be then quantified as well as the cross-sensitivity to others gases. Preliminary results and potenial industrialization of such devices will be introduced and at last discussed.

Keywords: Phthalocyanine; nanolayers; Surface Plasmon Resonance; Gratings; optical sensors; gaseous pollutants measurement; pollutant monitoring; industrial air control.

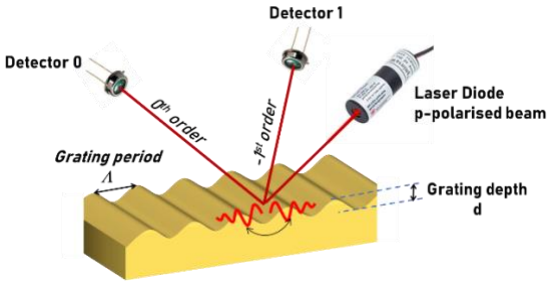

Figure 1: synoptic of SPR gas sensor.

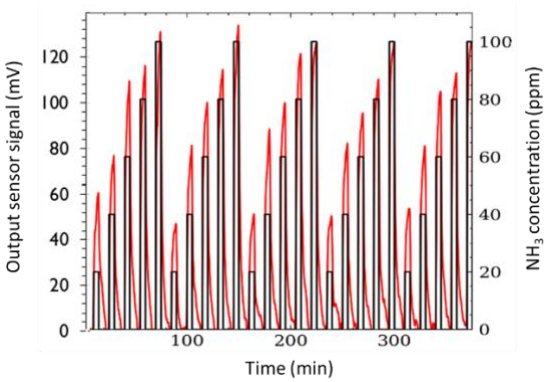

Figure 2: Dynamic response at room temperature of SPR sensor implementing optical grating coated by 50nm of CuPc exposed to 20, 40, 60, 80 and 100 ppm of NH_3.

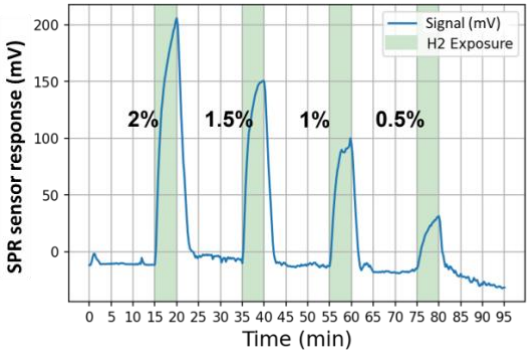

Figure 3: Output signal variations versus time of SPR sensor implementing 15 nm of Palladium as sensing layer coated on optical grating for various hydrogen exposure sequences in the 0,5-2% concentration range. Measurements are performed at room temperature in pure air.

SMS / NanoMed / Sensors 2023 Joint Session II. C: Biosensors and sensors for medical applications

A disposable immunosensor for detection of salivary MMP-8 as biomarker of periodontitis

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Abstract:
Periodontitis is a disease found in the oral cavity which consists of a chronic inflammation of the periodontal tissues, due to the accumulation of dental plaque[1]. Periodontitis starts as a normal gingivitis and can progress onto a chronic and aggressive disease, with periodontal tissue destruction, leading to tooth mobility and tooth loss. Matrix metalloproteinase-8 (MMP-8) was demonstrated to be the most prevalent MMP in diseased periodontal tissue, gingival crevicular fluid (GCF) and saliva, whose concentration correlates with disease severity[2,3]. Various methods have been reported in literature for quantifying MMP-8 in oral fluids, such as enzyme-linked immunosorbent assay, time-resolved immunofluorescence assay and lateral-flow immunoassays. The only POC devices for salivary detection of MMP-8 available on the market are PerioSafe ® and Implant Safe ® dipstick immunotests, which combine lateral flow technology with ELISA detection.
Voltammetric immunosensors represent interesting alternatives, as they are low cost, fast, easy to use with possibility of POC analysis.
This work describes the development of a novel voltammetric immunosensor for the detection of salivary MMP-8. The electrochemical platform is based on a graphene screen-printed electrode (GPH/SPE) functionalized by gold-nanospheres[4] (AuNSs) and antibodies against MMP-8 protein (anti-MMP-8). The very good performances exhibited by the proposed biosensor allowed its use in real saliva samples, where it showed comparable results to the conventional ELISA method. Therefore, the anti-MMP-8/AuNSs/GPH/SPE based immunosensor may represent a promising tool for non-invasive screening of periodontitis at the POC.
To the best of our knowledge this is the very first time that a voltammetric immunosensor has been developed and applied for MMP-8 detection.

Keywords:

MMP-8; periodontitis; immunosensor; voltammetric biosensor; gold-nanospheres; human saliva.

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β-cyclodextrins grafted on magnetite@polynorepinephrine as a potential long-term mobile glucose biosensor

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Abstract:
A crucial step in the progress of medicine is the creation of efficient diagnostic techniques for the precise, easy, and quick detection of glucose in bodily fluids. Self-monitoring of glucose concentration is currently a standard component of diabetic mellitus treatment [1]. Moreover, nowadays, scientific describe various problems in commercial devices brought on by manufacturing processes, early ageing, improper storage, or erroneous use [2].
POCT (point-of-care testing) is a novel approach to laboratory testing. This method involves conducting diagnostic procedures near the patient's location [3]. The main approach is enable simple detection, requiring neither patient movement nor the involvement of the laboratory staff. Traditional and sophisticated test methods, which considerably increased the time of the analysis itself and ultimately delayed the potential of treating patients, are being replaced by the trend of POCT due to easy data sharing [4].
Herein, a new hybrid material, magnetite@polinorepinephrine@β-cyclodextrins were proposed. This matrix was used to immobilize the enzyme - glucose oxidase and finally to construct the enzymatic biosensor. This system is based on SPE electrodes (screen-printed electrode). The proposed system was and integrated with the world's smallest potentiostat in tandem with portable devices like smartphones or tablets.
The SPE/Fe_3O_4@PNE@βCD-GOx biosensor allowed to measure glucose in a broad concentration range (0.1-30.0 mM), with improved sensitivity (204.82 μA mM^{-1} cm^{-2}), a small limit of detection (3.2 μA), and a quick response (2.6 s).
The system also showed high selectivity for additional interfering agents, therefore it was then used on real solutions of glucose (human blood, human serum).The presented biosensor also attained long-term stability for up to 11 months.
The key feature was also that this biosensor complies with the most recent FDA regulations regarding the design of new glucometers.
The SPE/Fe_3O_4@PNE@βCD-GOx biosensor unveils an attractive alternative as a mobile point-of-care testing tool for glucose measurements. Additionally, it enables real-time measurements outside the laboratory.

Acknowledgments:
The work was financed and prepared by the Poznan University of Technology research grant no. 0912/SBAD/2306. Dr. Artur Jędrzak is also grateful to the Foundation for Polish Science (FNP) for its support through a START scholarship

Keywords: point-of-care testing, glucose biosensors, mobile-based detection, glucose oxidase

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Assessing SAR Levels in Microwave Sensors for Breast Cancer Detection: Ensuring Patient Safety

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Abstract:
In recent years, Microwave Sensors have shown promising potential for Breast Cancer Medical Imaging Applications due to their non-invasive nature, their specificity and ability to provide valuable diagnostic information thanks to the decomposition of materials principle [1], [2]. However, ensuring the safety of these sensors and their specific absorption rate (SAR) is of utmost importance to protect patients from potential harm. This study presents a comprehensive assessment method for validating the safe use of Microwave Sensors in Breast Cancer Medical Imaging Applications. The assessment method incorporates COMSOL Multiphysics simulations, which take into account the breast tissues, materials, RF sensors, and their space-position parameters. By utilizing these simulations, the study aims to achieve an optimal specific absorption rate below the limits set by regulatory bodies such as the Federal Communications Commission (FCC) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [3].
One crucial aspect of this study is the development of realistic models with accurate dielectric properties as they are essentiel for Radar and Tomographic Microwave Imaging Systems. These models incorporate heterogeneous mimicking Breast Tissues, including Skin, Breast-Fat, Gland, Muscle, and Tumor, to evaluate SAR and safety parameters in a more accurate representation of real-world scenarios.
To meet the requirements of clinical application and regulatory compliance, the developed models are tested using ultrawideband frequencies ranging from 3.4 GHz to 8.5 GHz, aligning with the unlicensed spectrum range specified by the FCC and the European Telecommunications Standards Institute (ETSI) [4].
This research encompasses both qualitative and quantitative analyses. The outcomes of this study enables safer and more accurate Breast Cancer diagnoses while ensuring adherence to regulatory limits, thus providing personalized patient care.

Keywords: Microwave Sensors, Breast Cancer, Meddical Imaging, Specific Abosrption Rate (SAR), RF simulations.

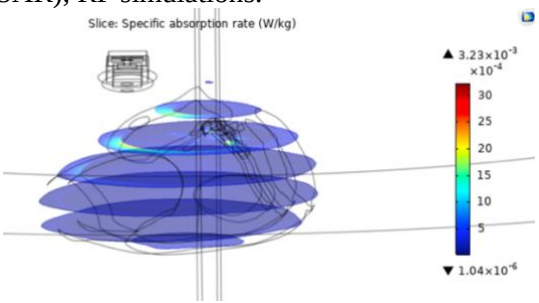

Figure 1: SAR levels on a breast heterogeneous model, with acceptable FCC and ETSI values, less than $1x10^{-3}$ W/Kg (1g).

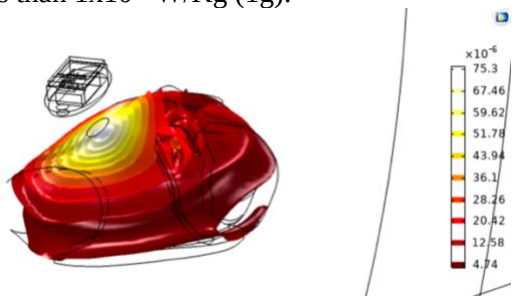

Figure 2: Same simulation but about the heat effect on the breast, values less than $1x10^{-5}$ Cº.

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In-Situ Investigation of Cellular Level Biomarkers Using Atomic Force Microscopy(AFM) Based Nano Robot

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Abstract:
It's imperviously demand on high adaptive and non-destructive techniques without the compromise of the resolution to investigate synthetic and biological samples in nanoscale. As a sensing device in nanoscale dimension, atomic force microscopy (AFM) has the priority of simultaneously derive multi-parametric information from objectives with sub-nanometer spatial resolution. The unique mechanisms of the AFM architecture could minimize the damage exert on the samples by monitoring the force-sensing cantilever probe motion with laser reflection. Based on the controllable tip-cantilever architecture of AFM, the probe could be considered as a self-sensing robotic end effector[1]. Based on above consideration, multiply nanomechanical sensors, auxiliary systems, force sensing and imaging algorithms have been implemented to enhance the capability of sensing in conventional AFM(Fig.1). Combining developed AFM-based nanorobot systems with label free mechanical biomarkers contributes to the investigation in cellular level and provide the stable and harmless way for pathological and clinical research. To quantitatively sense the cellular viscoelastic besides from near membrane region of cell, the external high-speed actuator with piezoelectric sensor has been implemented to excite cell with mechanical vibration which transmits from basal area of the cell to the membrane.With the probe sensing on the membrane of the cell, the comprehensive mechanical profile throughout the whole cellular architecture with the high spatial-temporal resolution could be measured while the traditional microrheology and force indentation experiment could only measure the information near membrane(Fig.2). Besides, the augmentation reality robotic system with stereoscopic vision, haptic controller, position recovery scheme, and real-time force control have been implemented in the system to enhance the capability of manipulation and disassembly of nanoscale objects such as virus capsid (Fig.3).

Keywords: Nanorobotic, mechanical biomarkers, atomic force microscopy, living cell, nanomanipulation, in-situ measurement.

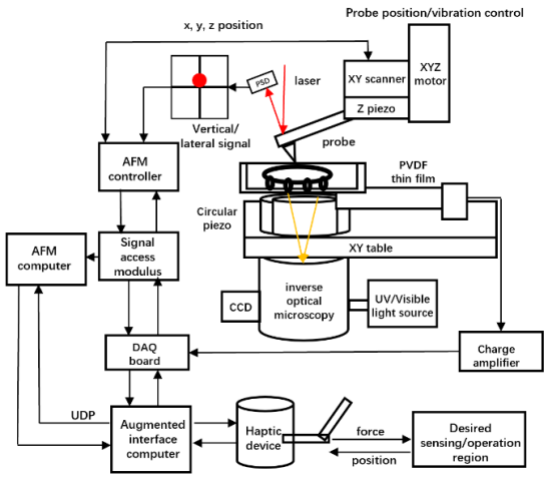

Figure 1: Schematic of AFM based nanorobotic system in bioorganisms measurement and manipulation.

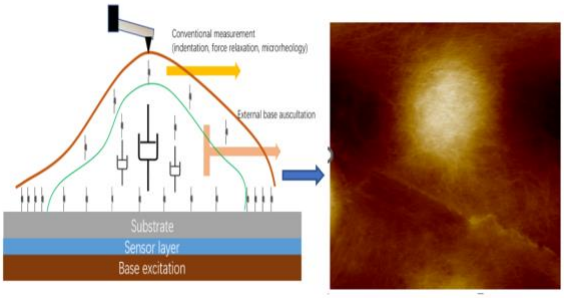

Figure 2: Deep auscultation on the living embryonic stem cell.

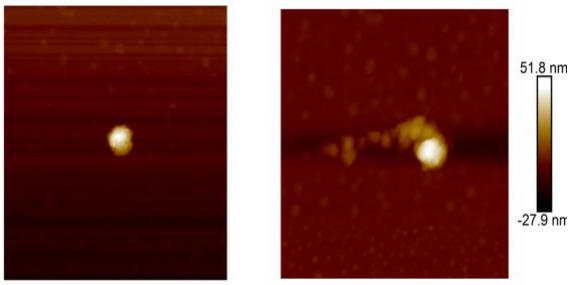

Figure 3: Single viruses disassembling by AFM based nanorobot.

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Pioneering Disease Diagnosis Platform: Leveraging Differential Dynamic Microscopy

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2) Department of Chemical Engineering, Polytechnique Montréal, Montreal, H3C 3A7, Canada
3) School of Physics and Astronomy, University of Edinburgh, Peter Guthrie Tait Road, Edinburgh, EH9 3FD, UK

Abstract:
We introduce a pioneering application of differential dynamic microscopy (DDM) for disease diagnosis. The principle is based on monitoring the dynamic signal of originally non-fluorescent probe beads. When the target antibodies bind to the probe beads, however, probe beads become fluorescent via the addition of fluorescently-labelled secondary antibodies. Utilizing standard epi-fluorescence microscopy, DDM effectively captures and distinguishes the fluorescence emanating from the probe beads. By tracking the Brownian motion of probe beads, DDM quantifies the fluctuations in scattered light originating from them, isolating them from background signal attributable to unbound fluorescent secondary antibodies. This information can then be correlated with the concentration of the target biomarker. We demonstrate this by empolying probe beads functionalized with SARS-CoV-2's spike protein receptor binding domain (RBD). Our findings suggest that by adjusting imaging parameters and sample processing, we surpass clinical detection limits in saliva and serum samples. Our method offers advantages over traditional methods like ELISA and PCR in terms of simplicity and versatility without specialized equipment. Therefore, the potential application of DDM-based disease diagnostics extends to numerous laboratories, particularly those in remote areas with limited resources. Additionally, the possibility of point-of-use applications exists through the miniaturization of the imaging setup.

Keywords: biomarker detection, immunoassay, protein corona, diagnostic, SARS-CoV-2

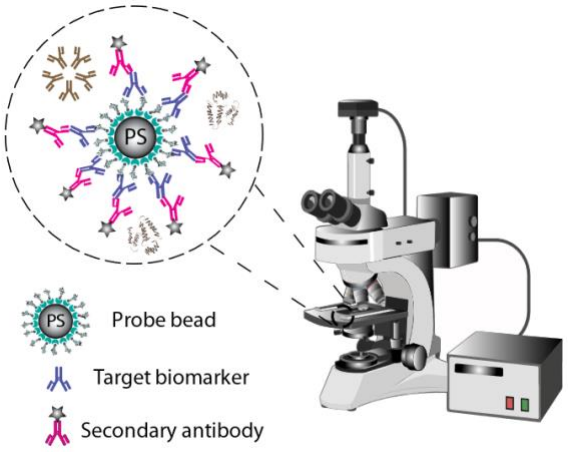

Figure 1: Illustration of the method for quantification of the target antibodies on the probe beads. First step is to incubate the Spike-RBD coupled probe beads and fluorescently labelled secondary antibodies with the sample containing the target antibodies. Then, the suspension is injected into a glass capillary for fluorescence microscopy imaging. After a series of mathematical calculations, the concentration of the target antibody is finally determined via a calibration curve.

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Controlled Design of Aptasensing Platforms for Food Contaminants Detection through Aryl Diazonium Electrochemistry

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Abstract:

The adoption of rapid, affordable, easy-to-use, sensitive and specific techniques able to detect a wide range of food contaminants represents a crucial step in improving the food quality and safety. Electrochemical aptamer-based biosensors are increasingly being recognized as capable to fulfill the above demands, due to their remarkable advantages in terms of degree of control of the electrochemical methods, high binding affinity of the aptamers for their target, and the possibility to achieve ultrasensitive detection at effective cost. The current work exploits the significant advantages of diazonium electrochemistry[1] for developing stable, reproducible and selective electrochemical aptasensing platforms to be applied for food contaminants detection. In order to impede the formation of multilayers, and to allow the further coupling of recognition species by "click" chemistry, we employ in the grafting process protected ethynylphenyl diazonium salts[2]. We also demonstrate that both the aptamer surface density, and the analytical performance of the proof-of-concept developed aptasensors can be modulated via the size of the protecting group. Given our stated goal of developing electrochemical aptasensors that can operate in complex food matrices, we have also tested the fabrication of bifunctional sensing surfaces by the coupling of both aptamer sequences and phosphorylcholine zwitterionic species[3] at ethynylphenyl modified electrodes. These species limit the biofouling processes, and display low impedance being compatible with the amperometric detection strategies.

Keywords: aryldiazonium chemistry, electrochemical aptasensors, antifouling, amperometric detection

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Detection of highly diluted single-nucleotide polymorphism in healthy DNA using graphene field-effect transistors

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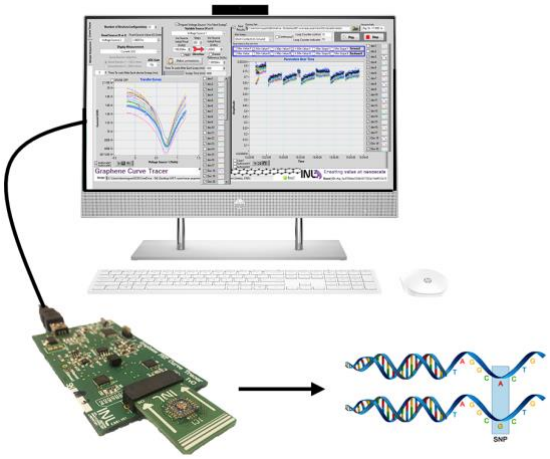
Abstract:
Malignant gliomas are the most common primary brain tumors in the central nervous system with poor prognosis. They are currently detected by expensive and invasive techniques, effective only when the disease is already in advanced stages. Recently, early brain tumor diagnosis by detecting trace amounts of circulating tumor DNA in liquid biopsies was demonstrated. This finding could be a game changer in the fight against brain cancer if new versatile biosensing technology is available [1]. This work develops a novel graphene ion-sensitive transistor with an unprecedented low limit of detection. The signal comes from the local gating of the graphene transistor channel, directly exposed to the analyte in solution. The specificity for the target stems from graphene functionalization with synthetic DNA immobilized by non-covalent chemistry. The graphene field-effect transistor (GFET) chip was integrated with a miniaturized Arduino-compatible reader that provides an easy and "within-seconds" route toward DNA detection [2].
A small amount of mutated synthetic DNA is mixed with a large amount of healthy DNA in a proportion similar to the expected occurrence in clinical samples, e.g., 0.1:100; 1:100; and 10:100. The sensors show sensitivity to the detection of the mutated DNA even though it differs only by one base (single-nucleotide polymorphism) from the unmutated sequence. The lowest mutated DNA detection level was in the femtomolar range. Experiments were performed in synthetic phosphate buffer, spiked undiluted human plasma, and diluted buffer. With an increase of dilution from 1× to 50×, a reversal of the output signal, from negative to positive, is observed. A plasma dilution of 25× enabled biosensing results similar to those in an artificial buffer.
These findings denote the potential of graphene field-effect transistors for the escalated level of detection of circulating tumor DNA in a complex matrix.

Keywords: brain tumors, graphene transistors, early detection, personalized medicine, circulating tumor DNA, liquid biopsy.

a.



b.

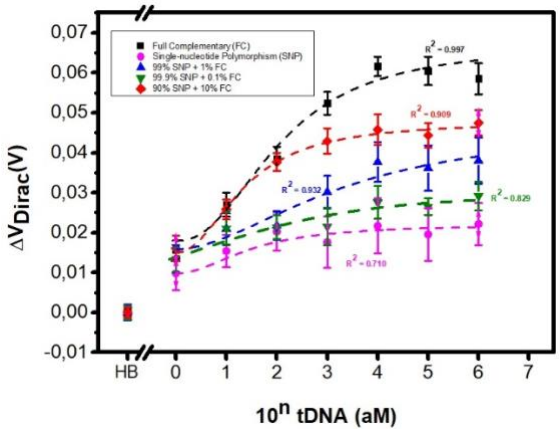


Figure 1: a. The microsensor is based on a graphene-FET array; b. calibration curve in phosphate buffer for mutated DNA mixed with healthy DNA (0.1:100; 1:100; 10:100).

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NanoMed / Sensors joint Session II. A: Bioinspired, Biomimetic bioactive biomaterials
Intelligent drug delivery and release system

Nanotechnology-based assessment of *Flavivirus* assembly and its inhibition

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Abstract:
Flavivirus are highly relevant viruses for human health, namely dengue (DENV), Zika (ZIKV) and West Nile (WNV) viruses, which are closely related, sharing structural features, as shown by us and others. The virion contains a nucleocapsid core, comprising a positive sense single-stranded RNA genome bound to multiple capsid (C) protein copies. The core is surrounded by a lipid bilayer containing the envelope and membrane proteins. The C protein mediates assembly and encapsidation, key steps of the viral life cycle, being highly conserved, and it is able to bind both to host lipid systems and to the viral RNA.

DENV C interacts with host intracellular lipid droplets (LD) and affects host metabolism, a crucial step for viral replication. We found that an amino acid sequence within C protein N-terminal is conserved among flaviviruses and essential for DENV C-LD binding. The discovery of this conserved motif led us to design and patent a drug lead, pep14-23 (patent WO/2012159187/A3), that successfully inhibits DENV C-LD interaction. DENV C N-terminal region, homologous to pep14-23, confers plasticity to DENV C structure. These variations between conformations allow the interaction of this protein with different targets. Indeed, as shown by us, DENV C interacts with perilipin 3 (PLIN3), a LD surface protein, and apolipoprotein E (APOE), a structurally analogous surface protein of very low-density lipoproteins (VLDL). We found that WNV C also interacts with host LDs and VLDL, likely binding to PLIN3 and APOE, respectively. In DENV, association to LDs is essential for viral replication, while binding to VLDL may enable the formation of highly infectious lipoviralparticles. Thus, inhibiting interactions with both host lipid systems (LDs and VLDL) may be crucial for successful therapies, which pep14-23 enables. Combining bioinformatics, nanotechnology and biophysics, we further analyzed pep14-23 structure and its ability to bind different phospholipids, relating that information with the full-length DENV C. DENV C N-terminal segment revealed four viable homodimer orientations that alternatively shield or expose the DENV C hydrophobic pocket. These findings show that the disordered N-terminal region can indeed act as an autoinhibitory domain, mediating DENV C interaction with its biological targets, with pep14-23 structure exploring that autoinhibitory activity. WNV C also binds LDs in a specific manner and similar observations are found for ZIKV C, with minor but important variations.

Given the above, we proceeded towards the final frontier, meaning to understand and inhibit the C protein binding to the viral RNA. It is hypothesized that the positively charged C protein binds the negatively charged viral RNA via the α4-α4' interface, assisting in viral genome packaging. *Flavivirus* C proteins bind RNA in a manner whereby the nucleotide sequence and genome structure seem to be key factors. In fact, notwithstanding a role for pure electrostatics-based interactions, we recently identified specific C protein binding spots within the viral RNA genome. We are now using that information to develop ssDNA analogues of those regions of the viral genome to which the C protein has high propensity to bind. These serve as leads in drug development and to map RNA binding spots within the C protein. This follows on our nuclear magnetic resonance (NMR) studies with this protein, which allowed to identify the LDs binding spot within the C protein, enabling to design and improve pep14-23. Having key ssDNA sequences identified may allow us to develop and/or repurpose inhibitors (including ssDNA-based analogues) against such interactions. Inhibiting simultaneously several viral mechanisms prevents a virus from developing resistance to each individual mechanism-centered drug. Blocking DENV C from binding host lipid systems and the viral RNA would effectively target two independent mechanisms to stop viral replication.

Keywords: *Flavivirus*, dengue virus, Zika virus, West Nile virus, capsid protein, lipid droplet, VLDL, RNA, ssDNA, atomic force microscopy, force spectroscopy, NMR, circular dichroism, fluorescence spectroscopy, dynmic light scattering, zeta potential.

Nanocrystals as novel nanomedicines in cancer

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Abstract:
Nanomedicine represents alternative solutions to treat patients with cancer limiting toxicity to certain organs related to large systemic amount of drug and providing better accumulation in vascularized tumors. Despite the encapsulation of drugs into nanomedicine, the amount of drugs reaching the tumors were however often considered too low, because of an insufficient encapsulation rate or a lack of stability inducing an unfortunate release of drug prior reaching the organ of interest. Therefore, reaching a higher encapsulation rate or a better stability could be strongly beneficial for nanomedicine in cancer.
In the UTCBS laboratory, we were interested in nanocrystals. NCs have shown their potential in the late 80s and about 20 NC drugs have been approved by the Food and Drug Administration by now in various diseases, although none as anticancer treatments. Therefore, the latter reinforces UTCBS' endeavors on developing anticancer drug NCs and the legitimacy of these nanoparticles as potent forthcoming delivery systems for nanomedicines[1].
During drug development, various processes involving the physicochemical modulation of active pharmaceutical ingredients (APIs) allow to overcome bioavailability issues[2]. Their engineering optimizes the therapeutic efficacy of drugs with enhanced safety profile, targeting efficiency, and suitability for administration through various routes. Among them, nanocrystallization stands out as it maximizes the loading of the API dispersed in liquid or solid dosage forms. In this context, the UTCBS laboratory pioneered the solvent/anti-solvent bottom-up approach using a minimal amount of polymer as a stabilizer to develop etoposide nanocrystals (NCs) for anticancer therapies[3]. We showed that etoposide toxicity was conserved in vitro. The anticancer effect of NCs etoposide was increased as regard to the pharmaceutical drug toposar in 3LL grafted tumor mice models. The method was applied to other drugs such as polyphenol and antioxydants showing the versatility of the approach[5].

Keywords: Nanocrystals, Fisetin, Etoposide, Nanomedicine.

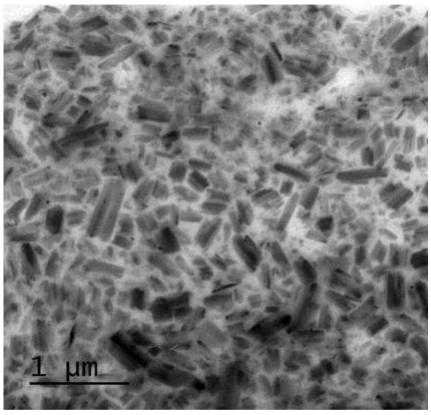

Figure 1: Transmission Electron Microscopy images of Fisetin nanocrystal suspension stabilized by Poloxamer 407[5].

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Hybrid PEM/wax coatings for surface biofunctionalization

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[2] NMI Natural and Medical Sciences Insitute at the University of Tübingen, Reutlingen, Germany

Abstract:
Controlling cell adhesion, viability, and proliferation on solid surfaces is critical for the successful implantation and proper functioning of medical implants. Polyelectrolyte multilayer (PEM) coatings represent a promising strategy for biofunctionalization of material surfaces. The insertion of non-polymeric components into polymer matrix is a strategy used to modulate PEM properties, which is expected to result in new attractive properties meeting the needs of specific application.

Here, we introduce nano thin innovative composite polyelectrolyte multilayer/wax (PEM/wax) coatings as a strategy for biofunctionalization of medical implants. We report the effect of integration of wax-nanoparticles on the properties of three types of PEM, comprising strong and weak polyelectrolytes and how these in turn impact coatings' ability to support cell adhesion and proliferation.

Our results show that all three types of PEM coating appear hydrophilic (static water contact angle in the range 50-70 degrees) but turn into hydrophobic after the incorporation of one or more wax-layers on top or in between the PEM layers (contact angle between 100 and 115 degrees). This switch in hydrophilicity affects the degree of protein adsorption at the surface, as well as adhesion and proliferation of 3T3 fibroblasts and Human Umbilical Vein Endothelial Cells (HUVEC). Figure 1 demonstrates the adhesion and proliferation of 3T3 fibroblasts, which exhibit higher overal surface activity compared to HUVEC cells, on three of the studied hybrid coatings. Furthermore, we demonstrate that not only surface hydrophobicity but also other surface properties contribute to governing the biological response of different PEM/wax coatings.

The analyses of albumin adsorption of the various PEM and PEM/wax coatings showed that the coatings with a positive surface charge exhibit a higher protein adsorption than the coatings with a negatively surface charge, due to the negative net charge of the albumin molecule.

The cytotoxicity evaluation of the developed coatings was carried out in accordance with ISO 10993-5 and demonstrated that all coatings are non cytotoxic which makes them very promising as coatings for medical debices.

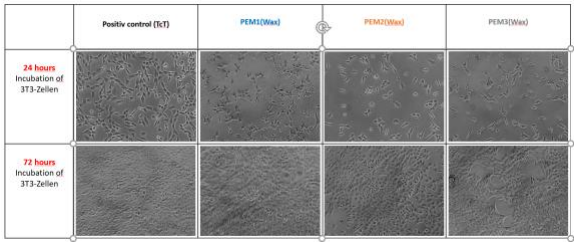

Figure 1: Microscopic images illustrating the adhesion and proliferation of 3T3 fibroblasts on PEM-based coatings with incorporated wax layers.

Keywords: biofunctionalization, polyelectrolyte multilayer coatings, thin hybrid films, cell adhesion, cell proliferation, protein adsorption, surface properties, hydrophilicity

Acknowledgements:
The authors gratefully acknowledge the funding by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) for the subproject 2 within the Research Unit FOR5250 "Permanent and bioresorbable implants with tailored functionality" (No. 449916462).

Bioinpired Nanopore Sensors Using Antibody Mimetic Technologies

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Abstract:
In this talk, I will dwell on recent developments in nanopore technologies that impact molecular biomedical diagnostics. Significant progress has been accomplished in protein analytics using nanopore-based techniques. However, creating generalizable nanopore sensors to detect proteins at a single-molecule level without the confinement of the pore interior remains challenging.[1, 2] We addresses this long-standing technological difficulty by formulating, developing, and validating a new class of sensing elements in single-molecule protein detection. The key ingredient of this technology is fusing an external programmable antibody-mimetic binder with a monomeric protein nanopore.[3] This strategy drastically expands the spectrum of applications of nanopore sensors to a broad range of proteins and biomarkers without altering their modular architecture, high specificity, and sensitivity. Notably, these nanopores operate in biofluids at clinically relevant concentration ranges of protein biomarkers and with an extended time bandwidth. In this case, the reporting signal unambiguously distinguishes protein recognition events at single-molecule precision without the requirement of utilizing complex analysis algorithms.

Keywords: protein folding, nanopores, protein engineering, single-molecule sensors, biosensor technology, protein biomarker, cancer diagnostics.

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Fast emitting scintillating nanocomposites for high resolution ToF-PET imaging

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Abstract:
The Time-of-Flight Positron Emission Tomography (ToF-PET) is a powerful imaging technique employed in a variety of medical fields. A radiotracer labelled with a radioactive isotope is injected into the patient and then it is attracted to areas of high metabolism, such as tumours. The isotope undergoes radioactive decay, releasing a positron which then annihilates with a surrounding electron producing two back-to-back γ photons with 511 keV energy. These γ-rays are then sensed by scintillating detectors placed around the patient's body and used to reconstruct the image of the radio-labelled tissue. One of the limiting factors of this technique is the detectors ability to discriminate the time of arrival of the γ-photons pairs, i.e. the coincidence time resolution CTR. The CTR should be as low as possible to improve the instrument sensitivity and the image signal-to-noise ratio at low radiotracers concentration. Much effort is put in the design of new scintillators aiming at a CTR < 50 ps, to surpass the limited performances of existing monolithic scintillators.[1] The concept of scintillating heterostructure has been proposed. Here the scintillator is fabricated by coupling heavy crystalline scintillators to a fast-emitting plastic scintillators to realize a multicomponent material. The dense component stops the γ-rays, and the fast emission of the plastic component is activated by the recombination of diffusing highly energetic recoil electrons generated by photoelectric effect in the dense component. This energy sharing mechanism is the key to possibly obtain the desired CTR. [2-3] To mitigate the low ability of the scintillating plastics to stop the ionizing radiation , due to their typical low density, we develop composite polymeric scintillator which density has been artificially increased by loading it with high density nanoparticles (HfO_2). In an optimized composition, we achieved a net improvement of the nanocomposite scintillation yield with respect to the performance of several commercial plastic scintillators. The composite has been used to fabricate a multilayer heterostructure where we observe the occurrence of energy sharing and achieving a time resolution below 200 ps. However, a detailed analysis of the scintillation and luminescence processes enabled to point out an unexpected interaction between the host matrix

and the embedded dyes upon excitation at high energy above the matrix optical bandgap, both with ionizing radiation or UV photons and independently from the employed dye. This interaction result in a slowdown of the dyes luminescence decay rate, thus heavily affecting the time response of the device. This critical point should be carefully understood and managed to avoid losing of the excellent fast emission properties of organic scintillators that can be exploited to achieve a time resolution below 50 ps for ToF-PET scanners exploiting scintillating composite scintillators.

Keywords: nanoparticles, HfO_2, heterostrucures, scintillation, energy transfer, ToF-PET, biomedical applications.

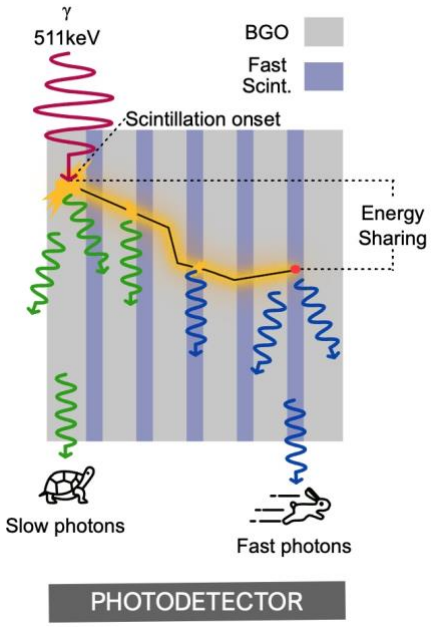

Figure 1: Figure illustrating the scintillation of hetherostuctures for ToF-PET application.

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Multifunctional Nanotubes for X-ray activated photodynamic therapy (X-PDT)

Valeria Secchi[1], Irene Villa[1], Chiara Villa[2], Yvan Torrente[2], Anna Vedda[1], Angelo Monguzzi[1]
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[2] Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico di Milano, Italy

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

Keywords: radiotherapy, scintillators, energy transfer, singlet oxygen, nanomaterials

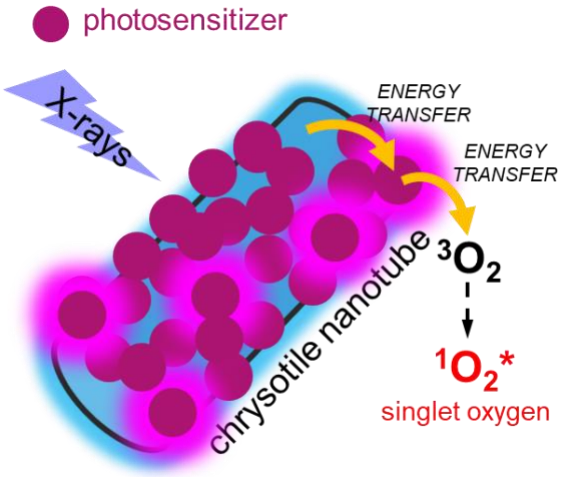

Figure 1: Sketch of a surface-functionalized scintillating chrysotile NT decorated with a singlet oxygen PS.

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SMS / NanoMed / Sensors 2023 joint Session II. B: Biomaterials / NanoBioMaterials / Bioimaging / Biosensors

New pharmaceutical formulations containing two-dimensional nanomaterials for phototherapy

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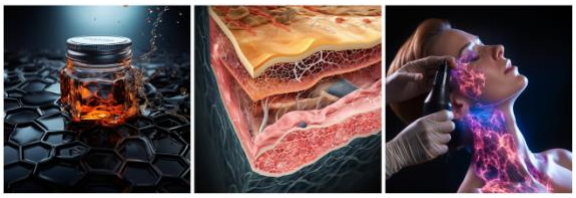
Abstract:

Photothermal therapy (PTT) using 2D nanomaterials (2DnMat) has recently emerged as a promising alternative treatment for cancer, a major global health challenge. High surface area, high extinction coefficient in near infra-red region, responsiveness to external stimuli, and the endless possibilities of surface functionalization, make 2DnMat ideal platforms for PTT. Most of these materials are biocompatible with mammalian cells, however, they must be comprehensively characterized physiochemically and biologically, since small variations can have significant biological impact. Despite the promising results, some challenges remain, such as improving 2DnMat conjugation with drugs, understanding their biodegradation, and refining the evaluation criteria to measure PTT effects. A never before reported partially-reduced nanographene oxide (p-rGOn) has been produced by nanographene oxide (GOn) photoreduction using light irradiation, yielding nanometric particles that preserve the original water stability, but acquire high light-to-heat conversion efficiency. Additionally, p-rGOn (150–250 µg mL-1) has been proven not to have impact on human skin fibroblasts (HFF-1) cell viability, after 24 h of incubation. Furthermore, an innovative custom-built near infrared (NIR) LED-system has developed and validated for 2D-nanomaterials photothermal effect evaluation. Nanomaterials were included in pharmaceutical formulations, and proven effective for skin cancer cells complete eradication, under near infrared irradiation, revealing also to permeate across human skin. A general perspective on the work of our team will be presented, focusing on applications of 2DnMat, with emphasis on graphene-based materials for phototherapy, immunotherapy, and 3D-printing for tissue regeneration [1-3].

Keywords: graphene, 2D-nanomaterials, phototherapy, cancer, biomedical applications.



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Synthesis of stable colloidal suspensions of non-superparamagnetic nanoparticles for magneto-rheology bio applications

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Abstract:
There is a widespread belief that non-superparamagnetic nanoparticles are not suitable for bio applications due to their tendency to aggregate and precipitate in aqueous media [1]. While this is true to a large extent, there is no fundamental principle preventing non-superparamagnetic nanoparticles to form stable suspensions in water. Here we present the synthesis of biocompatible aqueous stable colloidal suspensions made of non-superparamagnetic nanoparticles of a rare iron oxide, Al-doped ε-Fe2O3. These nanoparticles are synthesized by the sol-gel method and coated with a silica matrix to avoid their aggregation during the calcination step. A sodium hydroxide treatment is done to remove the silica matrix, allowing the nanoparticles to be suspended in a low pH solution forming a stable colloidal suspension. Coating the nanoparticles with a bio compatible polymer is the key step to a neutral pH and biocompatible aqueous stable colloidal suspension made of non-superparamagnetic nanoparticles. This synthesis opens new perspectives for the bio application of magnetic nanoparticles beyond the current applications of superparamagnetic nanoparticles. As an example, we show that the stability of the nanoferrofluid mixed with the strong coupling between the magnetic moment and the crystal lattice of non superparamagnetic nanoparticles allows a magneto-rehology sensing with high sensitivity [2], approaching the limits predicted for a rigid magnetic moment.

Keywords:superparamagnetic nanoparticles, alluminium doped epsilon iron oxide, , biocompatible stable colloidal suspensions, magneto-rehology.

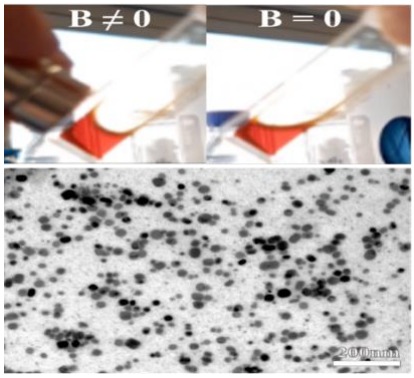

Figure 1: Picture of the ferrofluid at pH = 2 in the presence and absence of a magnet (top left and right, respectively) and an electron microscope image of the nanoparticles (bottom). In the absence of external magnetic field, the nanoparticles and their magnetic moment are free to rotate in the ferrofluid. The presence of the magnetic field exerts a torque on the magnetic moment which in turn is effectively transmitted to the nanoparticles, blocking their rotation degree of freedom in the ferrofluid.

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Acknowledgement The authors thank Hitachi for providing the STEM images. This work was supported by Grants PTDC/NAN-MAT/3901/2020 (supported by POCI, FEDER and FCT/MCTES) and CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 and LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). These results are part of project ThermoRise that has received funding from the European Research Council (ERC) under the European Union's Hori-zon 2020 research and innovation programme (Grant agreement No. ERC-2019-CoG-865437

Natural Receptors for Electrochemical Biosensors Assembly: The Case of IL-5Rα

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Abstract:
IL-5 is a homodimer stabilized by a disulfide bond that helps to orchestrate the immune response mediated by type 2 helper (Th2) cells. For example, monitoring IL-5, IL-4, and IL-13 levels may help screen relevant diseases like helminthiasis, type I hypersensitivities, and hypereosinophilic syndromes. Calculations of some variables like affinity and number of interactions sites of ligand–receptor interactions are determined *in vitro* by radioactive methods such as Scatchard plot or expensive ones like Bio-Layer Interferometry (BLI) or BIAcore. This work reports on a receptor-ligand interaction study by straightforwardly cost-effective electrochemical biosensors assembled with IL-5rα natural bioreceptors. Ni nanoparticles (NPs) were generated by galvanostatic electrodeposition onto a screen-printed carbon electrode (SPCE) and oxidized by cyclic voltammetry (CV) to link *in-house* produced his-tagged alfa chain of IL-5 receptor (IL-5Rα). We studied the NPs shape and electrode composition by X-ray photoelectron spectroscopy (XPS), field-emission scanning electron microscopy (FE-SEM), and energy-dispersive X-ray spectroscopy (EDS). The resultant device´s electrochemical behavior was studied by CV and electrochemical impedance spectroscopy (EIS). Our EIS records suggest that IL-5 leaves exposed a positive surface to the medium after interacting with IL-5Rα, which is congruent with previous studies. Thus, in contrast with other reported biorecognition elements for electrochemical biosensors assembly for the same purpose, our work suggests that a platform based on IL-5Rα natural receptors confers high selectivity power to detect challenging targets like cytokines.

Keywords: Electrochemical biosensor, cytokines, protein refolding, nickel-based nanostructures, biomedical applications

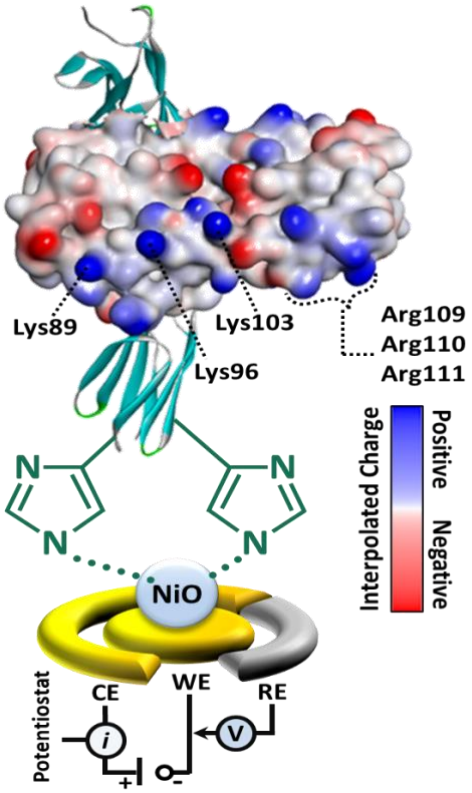

Figure 1: Platform architecture for IL-5 detection through its natural IL-5Rα His-tagged receptor. Oriented immobilization based on electrogenerated NiO nanostructures illustrates the relative simplicity of the assembly. Thus, conventional methods from different fields, such as biochemistry and electrochemistry, open the path to new ways of studying protein-protein interactions.

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Graphene Oxide: an efficacious Challenge for the Chronic Wounds management

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Abstract:
Chronic wounds are defined as wounds that do not heal in an orderly and timely way within 3 months, representing an important challenge worldwide. In a chronic wound, poly-microbial biofilms play a pivotal role in the pathogenesis of wounds impairing cutaneous healing. The increasing of multidrug resistant microorganisms strongly suggests the need for new and more effective antimicrobials for clinical application. Graphene Oxide (GO) is a good candidate for the chronic wound management due to its recognized antimicrobial and anti-biofilm properties. GO affected the planktonic and sessile growth of main chronic wound microorganisms: *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Candida albicans*. GO reduced the microbial growth by wrapping the microorganisms (Fig. 1) and increasing the ROS production (1). Moreover, GO was able to affect the microbial proliferation in *S. aureus* and *P. aeruginosa* dual-species biofilm, Lubbock Chronic Wound Biofilm (LCWB) model. It is a suitable *in vitro* model that mimcs the realistic microbial spatial proliferation in a human-like wound and its clot (2). In addition, in the LCWB, GO disaggregated and disruptied the fibrin network. The antimicrobial GO action was increased by the Light Emitting Diodes irradiation in the LCWB, representing a suitable eco-sustainable strategy to counteract the chronic wound microorganisms (3). The antimicrobial/anti-biofilm actions make the GO a promising tool for potential application in wound management.
This study will discuss the potential GO application to control and prevent the microbial proliferation in the chronic wounds.

Keywords: Chronic Wound Microorganisms, Graphene Oxide, antimicrobial action, anti-biofilm action, eco-sustainable strategy.

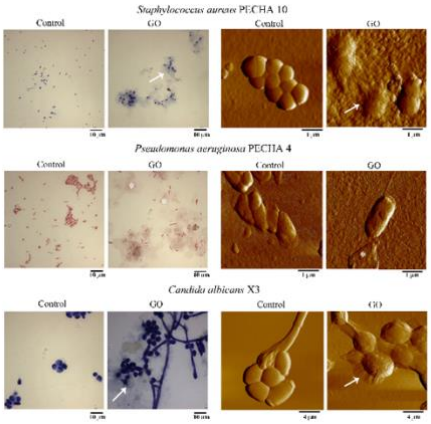

Figure 1: Effect of Graphene oxide (GO) at 50 mg/L on planktonic phase of *Staphylococcus aureus* PECHA 10, *Pseudomonas aeruginosa* PECHA 4 and *Candida albicans* X3. Representative images, Control and treated with GO, obtained with Gram staining (columns on the left) and AFM (columns on the right). Arrows indicate GO wrapping microganisms. Asterisks indicate the GO layer.

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Effect of biocompatibility in alginate 3D Scaffolds using calcium pyrophosphates (β-CPP) ceramics

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Abstract:
Calcium phosphates bioceramics influence the multimillion-dollar bone graft market and can be marketed in different ways, such as: injectable, in pieces, in cylindrical, block and 3D Scaffolds shapes. However nowadays studies of these biomaterials are related to its degradation rate into biologic systems. Among the calcium phosphates known the β-CPP biomaterials have faster degradation when compared to more traditional bioceramics, such as hydroxyapatite. Thus allowing a greater absorption into the physiological environment and being a potential alternative compound as a bone graft. Due to limitations regarding the general low mechanical resistance of these bioceramics, their association with other materials that have different physicochemical properties is proposed, making their application in bone grafting feasible. We report the β-CPP association with biopolymers alginate to allow the fabrication of a personalized porous structures for the formation of polymeric composites capable of mimetize natural structures, such as bone tissue (Figure 1). Furthermore, we will bring a discussion related to the challenges associated with the choose of a effective alginate matrix and the response to the cell adhesion and spreading through the 3D Scaffold. This study highlights the influence of β-CPP bioceramic, considered for the bone graft applications a unwanted by-product, but can stimulates a greater interaction between cells and pourous 3D structures observed by the presence of interconnected cells and diffused through the interior of scaffold. Besides that, this work also shows the improviment into the bone formation applications thus being able to expand this area in a more efficient, cheaper and safer way.

Keywords: Biomaterials, calcium phosphates, calcium pyrophosphates, 3D Scaffolds, pourous structure, polymeric composites.

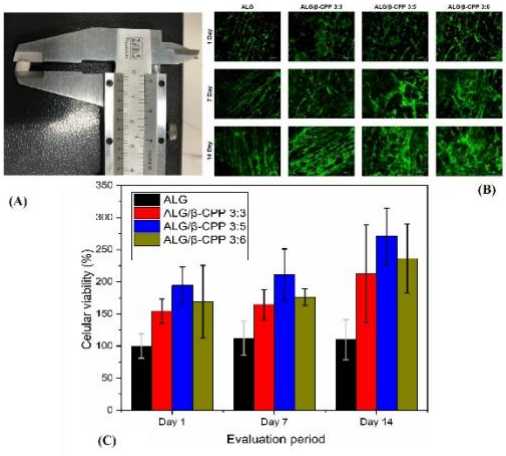

Figure 1: Representation of the 3D scaffold shape (A); fluorescence images from the cell viability assay (Live/Dead) of the Scaffolds (B); Viability of MC3T3-E1 pre-osteoblasts over 1, 7 and 14 days of cultures (C).

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Bioinspired Design for Additive Manufacturing Towards the Development of Innovative Devices for Biomedical and Industrial Applications

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Abstract:
The term "Additive Manufacturing" is relatd to a range of technologies which are based on a process of joining materials, layer by layer, in order to form complex structures. Such technologies were initially defined as "rapid prototyping" and today are commonly referred as "3D printing".
In this scenario, CAD tools provide a support for the ideation process, generating different design alternatives. As frequently reported, the geometric freedoms related to additive manufacturing can provide new challenges [1-3].
In particular, additive manufacturing has become an advanced processing method to develop custom-made devices with tailored properties, complex geometries and architectures.
Currently, design strategies may lead to the possibility of searching for a set of optimal solutions, in order to develop 3D additively manufactured devices with appropriate functional and structural properties, according to the specific application [1-3].
Topology and topography optimization, as well as generative design, can be considered as very powerful tools for the implementation of the product development process, providing functional parts and devices, which can most efficiently be fabricated using additive manufacturing technologies.
The research will explore the design of advanced and smart products, in the form of 3D solid, cellular, lattice or solid-lattice hybrid structures for biomedical (e.g. prostheses, scaffolds for tissue engineering) and industrial applications, also enhancing the product development efficiency.
A bioinspired design for additive manufacturing will favour the development of innovative products based on the extraction of novel wisdoms.
The research will be focused on the application of the biological knowledge in engineering innovation. The potential of bionspired design methods will be reported, also going beyond the concepts of biomimicry and biomimetics.
Keywords: Bioinspired Design, Design for Additive Manufacturing, Creativity and Innovation, Topology Optimization, Generative Design.

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Elimination of pathogenic E. coli bacteria using bioinspired plasmonic optical metasurfaces

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Abstract:
Bioinspired 3D nanostructured plasmonic metasurfaces, similar to those found on Cicada wings [1], were fabricated and used as effective antibacterial surfaces with the potential to reduce or, potentially, eliminate the use of antibiotics. The results of this study demonstrate an effective reduction in the number of viable bacteria grown on these bioinspired 3D nanostructures due to a synergic mechano-bactericidal and photothermal effect. In particular, combined bacterial exposure to the interfacial nanospikes as well as the evanescent blue and red electromagnetic fields induced by the nanoplasmonic metasurface, resulted in a 97% reduction of the viable E. coli in only 25 minutes, when illuminated with a low-power white light. Exposure to this light promotes surface plasmon resonance at the interface between the nanostructures and the bacteria (E. coli suspension in this study) [2] which, due to both texture and surface plasmonic activity, results in a significant decrease of the population of viable bacteria. It is also demonstrated that the bactericidal effect of the surfaces is mainly governed by their texture and the depth of the nanostructured undulations in total darkness. Under white light illumination, the antibacterial properties depend on the wavelength of the surface plasmon resonance being excited at the interface of the nanostructures and the bacterial layer. Exposure to the plasmonic evanescent wave in the blue region of the spectrum proved to be more effective at killing bacteria compared to red wavelengths. A combination of blue and red wavelengths had an even higher antibacterial effect than either one alone. A nanoplasmonic metasurface presented in this work, which produced both blue and red plasmonic wavelengths, enabled the 97% reduction in E. coli population after irradiation with low-intensity white light for only 25 min.

Keywords: Bioinspired, nanopatterning, metasurfaces, surface plasmon resonance, antibaterical surface.

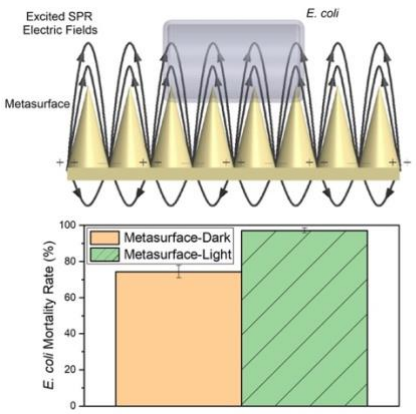

Figure 1: Top: Graphic representation of the fabricated nanospikes showing electromagnetic field lines created by the plasmonic resonance. Bottom: plot of the E. Coli mortality rate for the different metasurfaces in dark and under white light illumination.

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Interaction of Microparticles of Different Rigidities with Serum and Plasma Proteins

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Abstract:
Polyelectrolyte microparticles (MPs) and microcapsules with controllable characteristics obtained using layer-by-layer assembly are considered as promising tools for biomedical applications, such as drug delivery, theranostics, and biosensing[1]. Modification of the microcarriers with fluorescent labels, quantum dots, and magnetic particles expands the possibilities of their use in biophotonic applications[2]. Functionalization of the MP surface with specific recognizing molecules provides selective interaction with the target cells and increases their biocompatibility. After entering biological media, the surface of the particles absorbs proteins and other biomolecules from blood, which leads to the formation of an additional layer[3]. This layer can affect the physico-chemical and biochemical properties of the MPs and interfere with some biological processes, such as cellular uptake, immune response, clearance, and biodistribution[4]. In this study, we obtained two types of polyelectrolyte MPs with different rigidities, core/shell and shell MPs ("rigid" and "soft" MPs, respectively), to analyze differences in the composition of proteins absorbed on their surface after incubation in human serum or plasma. Spherical calcium carbonate cores with an average size of 2 μm were obtained in the presence of polyvinyl alcohol/methylcellulose solution in ultrapure water as a thickening agent. Polyelectrolyte MPs with the core/shell structure were obtained using layer-by-layer assembly, by depositing poly(allylamine hydrochloride) polycation (PAH), poly(sodium 4-styrenesulfonate) polyanion (PSS), and poly(acrylic acid) polyanion (PAA) layers. Dissolving the cores of the core/shell MPs resulted in the formation of hollow MPs. Both types of MPs had the shell structure $(PAH/PSS)_4/PAH/PAA$ and a strong negative surface charge. The "rigid" and "soft" MPs were incubated with human serum or plasma for 24 h at 37°C. Proteins adsorbed on the surface of the MPs were eluted using Laemmli sample buffer and separated by SDS-PAGE. The samples containing eluates from the surface of MPs were analyzed by means of mass-spectrometry. The results strongly confirmed the formation of a protein layer on the surface of the polyelectrolyte MPs, and the mass-spectrometry analysis revealed clear differences in the composition of the protein layer formed on the surface of the "rigid" and "soft" MPs after incubation with serum or plasma of healthy donors. The results of our study have implications not only for improving the design of drug delivery systems based on polyelectrolyte MPs, but also for understanting the fundamental mechanisms of interactions of the microcarriers differing in morphology and physico-chemical properties with human serum proteins.

Keywords: polyelectrolyte microparticles, polyelectrolyte microcapsules, protein adsorption, biomedical applications, mass-spectrometry, proteomic analysis.

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NanoMed 2023 Session II. C: Nanomaterials for Biomedical / Tissue engineering, drug, and gene delivery

Chameleon Nanocarriers for Delivery of Therapeutic RNA

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Abstract:
With Q2 2023, 26 gene therapies and 24 RNA therapies are approved as medical drugs. Nevertheless, dynamic and targeted intracellular delivery of RNA remains a key requirement. For refinements of nanocarriers we focus on a bioinspired, sequence-defined evolution strategy. This includes: (i) artificial amino acids such as tetraethylene pentamino succinic acid (Stp); (ii) the precise assembly into xenopeptide sequences by solid phase-assisted synthesis; (iii) screening of such xenopeptide libraries for nucleic acid delivery and selection of top candidates. A recent chemical evolution library combined an aminoethylene amino acid (Stp) as polar protonatable units with novel lipo amino fatty acids (LAFs) as hydrophobic protonatable motifs. These novel double pH-responsive nucleic acid carriers utilize intracellular delivery mechanisms of both cationizable lipids and cationic polymers. The endosomal pH-dependent tunable polarity of LAF was successfully implemented by a central tertiary amine, which disrupts the hydrophobic character once protonated, resulting in drastic pH-dependent change in the logarithmic (octanol/water) distribution logD from around +1 (pH 7.4) to -1 (pH 5.5). This "molecular chameleon character" turned out to be advantageous for mRNA, siRNA or CRISPER/Cas9 sgRNA delivery. The efficiency of best performers was up to several 100-fold higher compared to previous carriers. Transfection activity of mRNA lipoplexes was maintained even in the presence of 90% serum and at extremely low dosage of 3 pg mRNA (~2 nanoparticles/cell), in the range of the viral potency. mRNA lipoplexes showed great in vivo performance in mice with high expression levels in spleen, tumor, lung, and liver upon intravenous administration of 1 µg luciferase mRNA.

Keywords: delivery; evolution; mRNA; nucleic acid; sgRNA; siRNA; transfer.

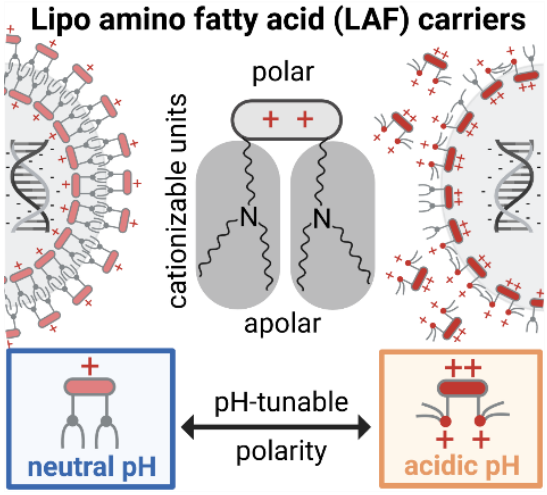

Figure 1: Figure illustrating dynamic pH-responsive xenopeptide carriers for RNA delivery based on polar Stp and apolar LAF. Figure created with BioRender.com.

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Self-assembly of Cyanidin 3-O-glucoside and negative charged polysaccharides. A structural study

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Abstract:
Anthocyanins are plant secondary metabolites with large therapeutic interest, widely applied because of their antioxidant, antiaging, anti-inflammatory, antidiabetic, anticancer properties. Cyanidin 3-O-glucoside (CND), one of the most widely abundant anthocyanins, is an unstable polyphenol that rapidly degrades when exposed to basic pH, high temperature, and oxygen. Biopolymer encapsulation is an extended method used to enhance biological availability of cyanidins. Here, for cyanidin encapsulation, we used sodium alginate, hyaluronic acid and chondroitin sulfate, highly hydrophilic, biodegradable biopolymer often used in food formulations and drug delivery. All these polysaccharides have different pKa and their negative charge depends on pH. CND's charge, chemical structure and color are also largely dependent on pH. Taking into account the pH dependence of charged forms of both CND and polysaccharides, complexes were prepared at pHs between 2.5 and 5 and characterized by UV, circular dichroism (CD), NMR, Dynamic Light Scattering (DLS), Small Angle X Ray Spectroscopy (SAXS) and Transmission Electron Microscopy (TEM). CD spectroscopy has shown that the interaction of CND with polysaccharides generates different chiral structures depending on polysaccharides nature and pH (Figure 1). TEM/SAXS hint on the formation of a compact supramolecular nanostructure in some cases made by fibers. Our results show how the tunning of pH can affect the organization of CND/polysaccharides complexes having an impact on CND loading, which is not purely based on electrostatic interactions. Our results bring fundamental knowledge for formulation of the CND in polymer complexes.

Keywords: Cyanidin 3-O-glucoside, polysaccharides, self assembly, chiral complex, nanofibers.

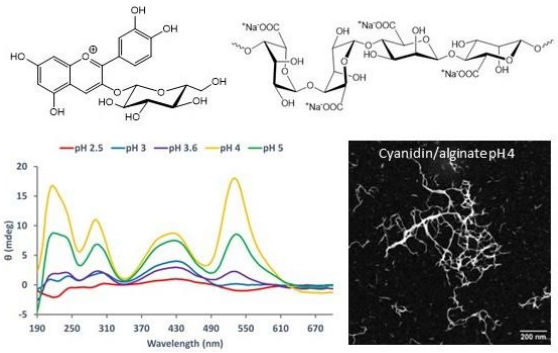

Figure 1: Molecular structure of cyanidin 3-O-glucoside and sodium alginate. CD of CND-alginate complexes at different pH and TEM at pH 4.

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Development of Stable and Biocompatible Super-paramagnetic Iron Oxide Nanoparticles (SPIONs) and Study of their Spatial Structuration upon the Application of an External Magnetic Field (MF)

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Abstract:
SPIONs have been investigated for decades and their use have been reported in various biomedical applications, such as hyperthermia, MRI contrast agents or drug delivery [1-3]. However, pure iron oxide aqueous suspensions are not stable at neutral pH, as they form large scale aggregates. Besides, they can present cytotoxic effects.
In this work, we firstly synthesized Fe_3O_4 based SPIONs ($\emptyset\ ca\ 10\ nm$) by co-precipitation method, using citric acid (CA) as electrostatic stabilizer (Fe_3O_4:CA) or/and chitosan (CS) as biocompatible coating (Fe_3O_4:CS and Fe_3O_4:CA:CS). In a second step, since such nanoparticles (NPs) may play the role of contrast agents in MRI, we studied their spatial structuration in aqueous suspensions upon an external DC magnetic field (MF) up to clinical 1.5 T (commonly used in MRI), by small angle X-ray scattering (SAXS) at the European Synchrotron Radiation Facility (ESRF/BM2-D2AM).
Results evidenced the aggregation of Fe_3O_4 and $Fe_3O_4{:}CS$ NPs, followed by a quick sedimentation and therefore no structuration upon MF. On the contrary, stabilized $Fe_3O_4{:}CA$ and $Fe_3O_4{:}CA{:}CS$ suspensions were found well dispersed, and formed spatially-oriented structures upon MF application (Fig. 1). Interestingly, the structuration was found reversible for $Fe_3O_4{:}CA$ NPs while it was not the case for $Fe_3O_4{:}CA{:}CS$ NPs, probably due to CS coating interdiffusion which locked the particles together after MF exposure.
This work shows a variety of physicochemical behaviors depending on the selected surface chemistry. Particularly, they open the way for the valorization of SPIONs exhibiting biocompatibility and true structural reversibility upon external DC MF for an easy renal clearance.

Keywords: Nanoparticles, Magnetism, SAXS, Chitosan, nanomedicine, biomedical applications.

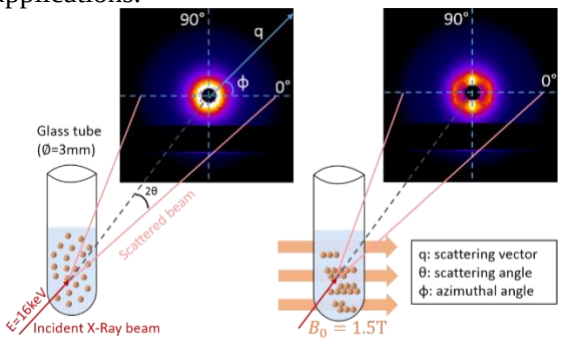

Figure 1: Evolution of 2D SAXS scattering patterns for a Fe_3O_4:CA SPION aqueous suspension upon the application of an external DC magnetic field.

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nanoTARG: a nanotechnological platform for the management of ZIP4-positive tumours

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Abstract:
ZIP4 is a transmembrane protein which has an anomalous expression in pancreatic ductal adenocarcinoma (PDAC),as well as in ovarian and pulmonary cancer. Thus being a specific target for delivery. At the moment pancreatic cancer is the 4th cause of cancer death but its expected that by 2040 it will become the 2nd leading cause of cancer death.[1] Therefore there is a need for a treatment with a higher efficacy as the overall survival rate is of an 8%.
Our group has prototyped a versatile nanotechnological platform where the targeting using ZIP4 monoclonal antibody (figure 1) leads to a selective accumulation of the active ingredients in ZIP4 expressing tumor cells via molecular recognition. The targeting efficacy was demonstrated *in vitro* and *in vivo*.[2] Moreover the nanoparticles enable passive targeting, are biodegradable and formed by FDA approved comoponents.
nanoTARG enables specific targeting to tumoral tissue in the pancreas and can potentially release the therapeutic gold standard to increase the survival rate of pancreatic cancer patients.

Keywords: targeting, cancer, nanocapsules, ZIP4, nanoTARG, nanomedicine, pancreatic ductal adenocarcinoma.

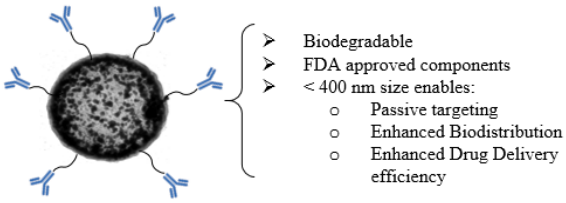

Figure 1: ZIP4 monoclonal antibody functionalized targeting nanocapsules.

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Designing an optical nanosensor to non-invasively monitor tumor metastasis

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Abstract
Triple-negative breast cancer (TNBC) accounts for 20% of breast cancer and tends to metastasize to the brain. For this reason, TNBC tumors have a higher rate of distant recurrence and with lower 5-year survival rate than other breast cancer. Zinc, an essential trace element and its aberrations involves closely with cancer progression and cellular dysfunction. In our work, we focus on sensing the potential relevance between zinc and TNBC metastasis. Based on surface enhanced Raman spectra (SERS) methodologies, zinc nano-sensor was designed. We chose the 2,2': 6'-2''-Terpyridine-4'-Thiol (TPY) as the sensing molecular and modified gold/silica nanocapsules (NCs) with TPY (NCs@TPY) to detect different amount of zinc in different metastatic TNBC cells. The tpy group can form stable complexes with Zn^{2+} and produced the relative SERS sensitive peak at 1034cm^{-1}. For chemoselective SERS analysis, zinc was determined by the ratiometric increase of a Raman peak at 1034 cm^{-1}, relative to the main peak at 1021cm^{-1}. Our work compared the different concentrations of zinc in MDA-MB-231 cell, brain metastasis model BrM_2 cell and lung metastasis model LM_2 cell, we found out Zn^{2+} concentration increased a lot inside the metastatic cells than the other cancer cell under same amount of Zn^{2+} incubated conditions. Our sensor with the LOD of $10^{-11.72}$ M is much lower than the Zn2+ standard methods by Zinquin. Herein a highly sensitive monitoring nanosensor for in situ zinc analysis inside single cell is presented.

Keywords: Biosensors, plasmonic nanoparticles, optical readout, SERS, zinc, metastasis.

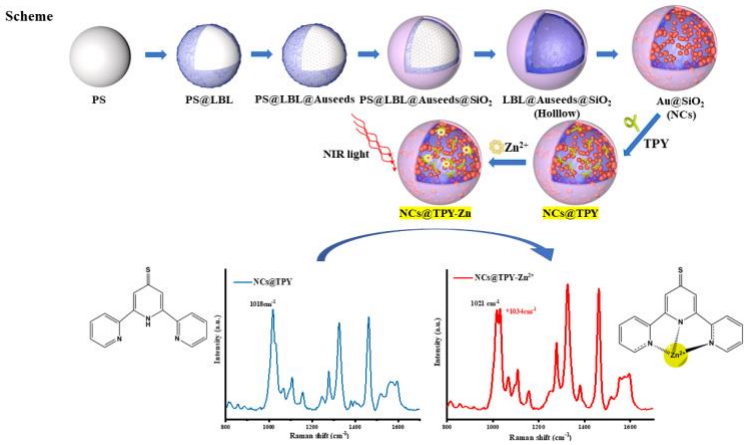

Figure 1: the scheme of zinc nanosensor. Based on the TPY characteristic molecule Raman signal, changes in intracellular zinc ion concentration are detected. After it combined with free zinc ions, the new Raman peak at 1034 cm^{-1} appeared, served 1034 cm^{-1} as the sensitive peak.

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Nanovesicles tested on human skin explants preserved In an innovative fluid dynamic system

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Abstract:
The impact that nanotechnologies are having nowdays on different fields, such as chemistry, energy and medicine, is remarkable. One possible biomedical application is the production of nanoparticles that could help in the delivery of drugs to their site of action in a more efficient way, increasing their bioavailability bypassing biological barriers, such as skin. With a view to test the ability of different types of vesicular nanocarriers to penetrate human skin, we exploited an innovative *in vitro* model based on human skin explants preserved in a fluid dynamic system[1,2]. The nanovesicles were applied topically on human skin explants maintained in this bioreactor until 72 hours, time frame in which tissue integrity is optimally preserved[1,2]. Their efficacy to penetrate into the deep layers of skin was tested with histological analysis, both at bright field and fluorescence microscopy, and with an ultrastructural analysis at transmission electron microscopy (TEM)[3,4]. Some results demonstrated that nanovesicles, previously studied by our group for up-take features in cultured cells[5,6], succeeded in penetrating the skin while preserving their structural integrity, but reaching different depth levels as a function of their peculiar physical-chemical characteristics[3]. Thus, our human skin model not only proved its suitability to act as an innovative biological barrier model *in vitro*, but provided original insights into the efficacy of nanovectors for topical administration.

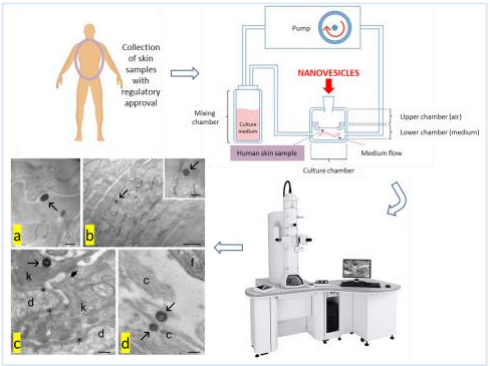

Figure 1: A graphical summary of the different phases of this study. TEM micrographs (**a**,**b**,**c**,**d**) show nanovesicles (indicated by *arrows*) penetrated into skin samples, specifically among corneocytes (**a**), inside a corneocyte (**b**), in the cytoplasm of a keratinocyte of the stratum basale (**c**) and in the extracellular matrix of the upper papillary dermis (**d**). *c*, collagen bundles; *k*, keratinocytes; *f*, fibroblast; *d*, dermis; *arrowhead*, well-preserved desmosome; *asterisks*, well-preserved junctions. Bars: 200 nm (**a**,**c**,**d**, inset in **b**); 1 µm (**b**).

Keywords: nanovesicles, fluid dynamic bioreactor, human skin explants, TEM

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Polymer carrier of cytotoxic drugs with P-gp-overcoming capacity in the treatment of chemoresistant tumors

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Abstract:
Chemotherapy is still the mainstay of cancer therapy. Indeed, cancer cells often fail to respond to chemotherapeutic regimens because of either inherent or acquired resistance. This is possibly the most important factor that determines success or failure of cancer therapy. One of the mechanisms developed during the treatment is an increased drug clearance by the transporter-facilitated efflux, resulting in (multi)drug resistance (MDR) of the cancer cells. It can be conferred by overexpression of transporters, such as adenosine triphosphate binding cassette (ABC) pumps, from which P-gp is probably the most prominent. Some recently developed drug delivery systems may represent a significant approach for overcoming this resistance.
Here, we used an amphiphilic diblock polymer nanotherapeutics containing a hydrophilic block based on the *N*-(2-hydroxypropyl)methacrylamide (HPMA) copolymer and a hydrophobic poly(propylene oxide) block (PPO). The amphiphilic character of the diblock polymer ensures self-assembly into micelles with hydrodynamic radius Rh ~15 nm in aqueous solutions (Figure 1). The carrier serves simultaneously as a drug delivery system and an inhibitor of MDR. Doxorubicin (Dox) was bound to the diblock po-lymer through a pH-sensitive hydrazone bond, enabling prolonged circulation in blood, tumor-specific delivery of Dox and subsequent stimuli-sensitive controlled release within the tumor mass at a decreased pH. The presence of PPO in the poly-mer carrier leads to inhibition of P-gp, depolarization of mitochondrial membrane potential, and ATP loss in the target cells. *In vivo*, the diblock polymer system proved an excellent EPR-driven therapeutic activity (Ref. 1). Importantly, significant therapeutic outcome was seen in chemoresistant tumors, such as murine CT26 colon carcinoma characterized by inherently elevated P-gp expression. Here we show mechanisms underlying activity of the HPMA-PPO-based polymer micellar carrier in several chemoresistant tumors.

Keywords: polymer micelles; drug delivery; EPR effect; doxorubicin; pH-responsive drug release; P-gp inhibition; anti-cancer therapy; overcoming multidrug resistance

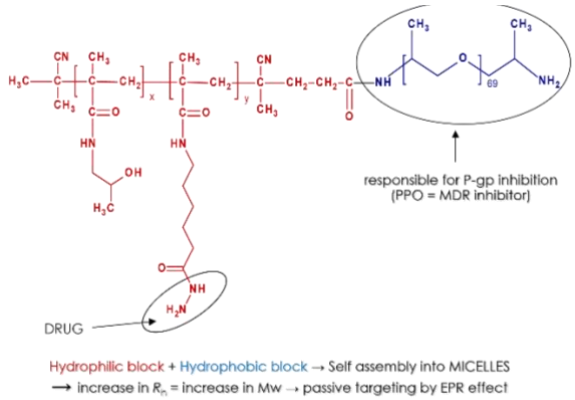

Figure 1: Scheme illustrating the structure of the HPMA-PPO diblock conjugate intended for tumor-specific drug delivery and overcoming P-gp activity.

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Acknowledgement: This work was supported by the Czech Health Research Council (project NU21-03-00273), by the project National Institute for Cancer Research (programme EXCELES, ID Project No. LX22NPO5102) - Founded by the European Union – Next Generation EU.

HPMA copolymer conjugates bearing novel STAT3 inhibitor and doxorubicin covalently linked through pH-sensitive bond possess in combination significant antitumor activity *in vivo*

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Abstract: Polymers based on *N*-(2-hydroxypropyl)methacrylamide (HPMA) were previously shown to be a superior carriers for various biologically active compounds including cytostatic drugs. In this study, we employed HPMA copolymers prepared by reversible addition−fragmentation chain transfer copolymerization with precisely defined molar mass (36.4 - 43.1 kDa) and highly narrow dispersity (Đ <1.1) bearing either doxorubicin or STAT3 inhibitor. We synthesized three novel derivatives (henceforth S3iD1-3) of previously described STAT3 inhibitors FLLL31 and 32 containing oxoheptanoic functional group enabling linkage to HPMA copolymer carrier via a pH-sensitive hydrazone bond. The *in vitro* cytostatic activity of S3iD1-3 was determined in panel of 5 mouse and human cancer cell lines of various origin (breast, colon and lung carcinoma, melanoma and leukemia) with IC_{50} ~ 0.6 – 7.9 μM. The most sensitive ones were mouse B16F10 melanoma (IC_{50} ~ 1.3 μM) and human acute myelogenous leukemia KASUMI (IC_{50} ~ 0.6 μM). Comparable *in vitro* cytostatic activities were found for polymer conjugates bearing S3iD1-3 (P-S3iD1-3). P-S3iD2 and 3 had undetectable toxicity in mice even at very high dosage *per se*, however, the combination with polymer conjugate bearing doxorubicin (P-Dox) exerted a considerable toxicity. The combination of P-S3iD3 and P-Dox using dosage with very low toxicity demonstrated a remarkable therapeutical effect in mice bearing progressively growing B16F10 tumors and led to complete cure in 2 out of 15 mice. P-Dox alone showed significantly lower therapeutic activity with no completely cured mice. Thus, we conclude that simultaneous delivery of STAT3 inhibitor and cytostatic drug may sensitize chemorefractory tumors.

Keywords: HPMA copolymers, controlled drug release, STAT3 inhibitor, doxorubicin, anticancer activity *in vivo*.

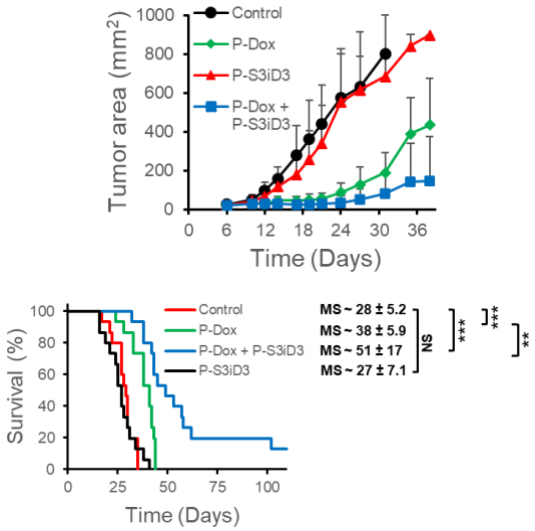

Figure 1. Antitumor activity of P-Dox and P-S3iD3 combined treatment *in vivo*. B6 mice were s.c. inoculated with 5 × 10^5 B16F10 cells on the shaved back on day 0. Mice were i.p. injected with P-Dox (20 mg Dox/kg per one dose) on days 6 and 10 and with P-S3iD3 (37.5 mg S3iD3/kg per one dose) on days 6, 7, 10 and 11. P-S3iD3 was administered several hours before P-Dox when both P-Dox and P-S3iD3 were injected on the same day. Control mice were i.p. injected with the same volume (300 μL) of PBS. Kinetics of tumor growth (upper graph) and survival (lower graph) were recorded. Mean survival (MS) ± SD of mice in each experimental group is shown. Pooled data from two independent experiments with n = 15 are shown. *** P ≤ 0.001; ** P ≤ 0.01; NS indicates no significant difference.

Acknowledgement: This work was supported by the Czech Health Research Council (project NU21-03-00273), by the project National Institute for Cancer Research (programme EXCELES, ID Project No. LX22NPO5102) - Founded by the European Union – Next Generation EU and by the Institutional Research Concept RVO 61388971.

Synthesis of *c*RGD functionalized nanosystems for tumor site-specific delivery of anticancer agents

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Abstract:

A promising approach to improve the chemotherapy efficacy in cancer treatment and, at the same time, reduce the related drawbacks is the development of targeted delivery systems.

The breakthrough of these systems is represented by the selective delivery of an anticancer agent to the tumour mass, thus increasing the local drug concentration while contemporary reducing the total amounts of administered drug and its systemic side effects.

Integrin $\alpha_V\beta_3$ and $\alpha_V\beta_5$, due to their overexpression on the surface of several cancer cell types and neoangiogenic vessels, represent ideal targets for this approach. Besides, these integrin receptors undergo internalization processes after ligand interactions, hence the payload of the delivery system can be released into the intracellular environment [1].

The use of $\alpha_V\beta_3$ and $\alpha_V\beta_5$ integrin antagonists such as small peptides carrying the Arg-Gly-Asp (RGD) sequence as selective drug carriers represents a particularly appealing strategy. In the last years these compounds were involved in clinical trials as anticancer agents, showing low toxicity towards healthy cells. The decoration of nanosystems with RGD-peptides would allow active targeting of nanoconstructs to tumours [2].

Here we report the synthesis of an RGD-based cyclopentapeptide (cRGD) with nanomolar IC_{50} towards $\alpha_V\beta_3$ and $\alpha_V\beta_5$ integrin receptors, and the chemical modifications which allowed its use as directing agent in drug delivery. The modified cRGD derivative was exploited to decorate the surface of silk fibroin nanoparticles [3] and lyposomes, which were then used to specifically target tumour cells. The obtained functionalized nanosystems showed to be very selective towards cancer cell lines of glioblastoma, triple-negative breast cancer, and other difficult-to-treat cancers overexpressing $\alpha_V\beta_3$ and $\alpha_V\beta_5$ integrins. The results so far obtained indicated that the modification of the nanosystems surface with cRGD derivatives could be a fruitful approach to enhance active targeting in tumor site-specific drug delivery, thus paving the way for in vivo studies and future applications in anticancer therapy

Keywords: RGD, nanoparticles, liposomes, cancer, drug-delivery, integrins

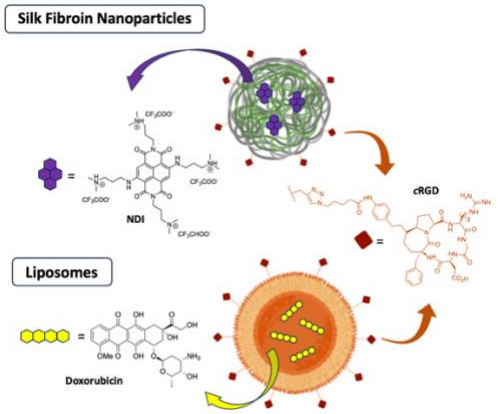

Figure 1: cRGD functionalization of silk fibroin nanoparticles and liposomes loaded with potent anticancer agents such as naphthalene diimides (NDIs) and doxorubicin.

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Design and optimization of nano-formulations for a novel colchicine derivative

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Abstract:
Chemotherapy is the most successful and reliable approach to cancer treatment. Nevertheless, it is often associated with side effects due to the intrinsic toxicity and non-selectivity of anti-cancer compounds [1].
CCI-001 is a novel colchicine derivative, computationally designed by modifying colchicine's basic structure, that exploits the affinity with βIII-tubulin to exert its anticancer activity [2]. CCI-001 ultimately leads to apoptosis of cancer cells by impairing mitosis. Compared to Colchicine, CCI-001 showed lower general toxicity, increased selectivity and specificity, and was proven to be effective on several cancer cells resistant to paclitaxel chemotherapy [2]. Despite this, its applications are limited by the extremely low water solubility, poor tumor uptake, and high non-specific distribution [2]. This may reduce CCI-001 efficacy and produce undesirable side effects. To solve this issue, this contribution describes the design of new efficient transporters of CCI-001 (polymeric nanoparticles, NPs) to enhance target accumulation and reduce off-target effects of the compound.
CCI-001 was successfully loaded in core-shell pegylated NPs, using the nanoprecipitation method [3]. In detail, a poly-ε-caprolactone (PCL)-based polyurethane (NHSC2000) was solubilized in acetonitrile and precipitated in water containing a mix of phospholipids (L-α-phosphatidylglycerol, PG and 1,2 – Distearoyl-sn – glycerol – 3 – phosphoethanolamine - Poly (ethylene glycol), DSPE-PEG). NPs of small size (~170 nm), narrow size distribution (PDI below 0.3), high stability in aqueous solution, and satisfying encapsulation efficiency (6 %) were successfully obtained [4].
In vitro efficacy of CCI-001-loaded NPs was analyzed against different cell lines, namely U87MG (glioblastoma multiforme), Mia-PaCa-2 (pancreatic adenocarcinoma) and OVCAR-3 (ovarian cancer).
CCI-001-loaded NPs caused a significant decrease in the viability of each of the tested cell lines. The maximum effect was exerted after 72h, at a concentration of 2,5 μM, where residual viability of 50%, 30%, and 26% were reached for U87MG, Mia-PaCa-2, and OVCAR-3, respectively (*Figure 1*).
Moreover, empty NPs did not elicit evident signs of toxicity on these cell lines, up to a concentration of 1 mg/ml.
Overall, our results demonstrate that nano-formulations of CCI-001 can be obtained with satisfying loading efficacy without altering the anti-cancer effect of the drug, warranting their further investigation.

Keywords: Nanoparticles, Nanomedicine, Cancer targeting, Colchicine, βIII-tubulin.

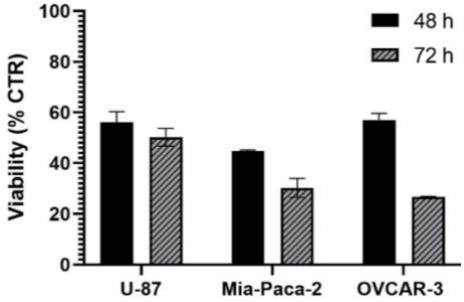

Figure 1: Cell viability of U-87, Mia-PaCa-2, and OVCAR-3 cells after treatment with CCI-001-loaded NPs at 2,5μM of CCI-001 concentration, measured after 48 h and 72h. (P<0,0001)

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Engineering Efficient Car-T Cells via Electroactive Nanoinjection

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Abstract:

Chimeric antigen receptor (CAR)-T therapy has emerged as a promising cell-based immunotherapy approach for treating blood disorders and cancers, but genetically engineering CAR-T cells is challenging due to primary T cells' sensitivity to conventional gene delivery approaches. The current viral-based method can typically involve significant operating costs and biosafety hurdles, while bulk electroporation can lead to poor cell viability and functionality.

Methods: Nanoinjection—the process of intracellular delivery using nanoneedles (NNs)—is a new physical delivery route that efficiently negotiates the plasma membrane[1-3]. Applying a novel electroactive nanoinjection (ENI) platform—the process of using electroactive nanoneedles (NNs) for intracellular delivery—has enabled the capacity to control the delivery of advanced therapeutics (chimeric antigen receptor (CAR) constructs) into human primary T cells[4].

Results: ENI technology has showed an efficient delivery (68.7%) and expression (43.3%) of CAR genes in the human primary T cells, with minimal cellular perturbation (>90% cell viability). Compared to conventional bulk electroporation (BEP), the ENI platform achieves an almost 3-fold higher CAR transfection efficiency, indicated by the significantly higher reporter GFP expression (43.3% compared to 16.3%). By co-culturing with target lymphoma Raji cells, we prove the ENI-transfected CAR-T cells' ability to effectively suppress lymphoma cell growth (86.9% cytotoxicity).

Conclusion: Taken together, the results demonstrate the platform's remarkable capacity to generate functional and effective anti-lymphoma CAR-T cells. Given the growing potential of cell-based immunotherapies, we anticipate that a non-viral and efficient nanoinjection platform like the one described here will offer a promising avenue for ex vivo cell engineering, particularly in the context of CAR-T cell therapy.

Keywords: smart materials, nanoelectroporation, nanoinjection, intracellular delivery

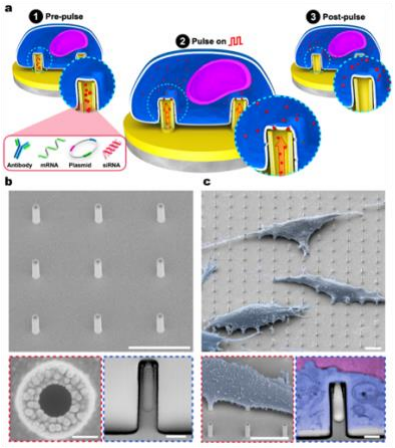

Figure 1. The ENI platform. (a) The steps of the ENI at point of contact between plasma membrane and NT. (b) The ENI platform was characterised through FIB-SEM. The close-up shows top-view of Au coated SiNTs. The close-up shows a cross-sectional FIB-SEM image of sputter-coated Au-SiNTs. Scale bars, 2 µm (main), 500 nm (red inset), and 100 nm (blue inset). (c) SEM images of fibroblast GPE-86 cells on ENI arrays (Scale bars, 10 µm (main), 5 µm (red inset), and 500 nm (blue inset).

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Platinum nanoparticles synthesized with lumichrome for UV-light cancer therapy

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Abstract:

Lumichrome (LC) is a nontoxic molecule that is involved in many biological processes and is also a fluorescent dye. However, the main biochemical interest on LC is due to its abilities as a triplet photosensitizer (PS) to generate singlet oxygen ($^1O_2$), thus it can be used in photodynamic therapy (PDT) against cancer. LC has also many other industrial applications, such as fluorescent probe, metal ion sensor, inactivation of biological contaminants and in memory and semiconductor devices [1].

The conjugation of LC with metal nanoparticles can have a dual effect: it can improve the bioavailability of LC and can have a synergistic effect owing to increased passive selectivity, contributing to a better antitumoral effect. Among other metal, platinum nanoparticles (PtNP) are a great candidate for biomedical applications since they're biocompatible, stable and exhibit interesting surface chemistry [2].

Therefore, in this work, the synthesis of 54 ± 8 nm platinum nanoparticles was achieved by direct reduction with lumichrome (Pt@LC). The Pt@LC were characterized by UV-Vis and fluorescence spectroscopy, high-resolution transmission electron microscopy (HRTEM), energy dispersive x-ray analysis (EDX), zeta-potential and dynamic light scattering among other techniques.

Finally, the biological activity was studied by exposing adenocarcinoma cells A549 to 300 µg/mL of Pt@LC for 24 hours and irradiating them with UV-A light (wavelength 375 nm) for 2 hours. Cell viability assays were performed and the oxidative stress was evaluated, by determining intracellular levels of glutathione and the gene expression of heme oxygenase-1 (HO-1), enzyme involved in the modulation of oxidative stress.

The treatment showed (Figure 1) a decrease in proliferation and a gain in oxidative stress, both increased by UV irradiation.

Keywords: lumichrome, photosensitizer, photodynamic therapy, platinum nanoparticles, antitumoral, oxidative stress.

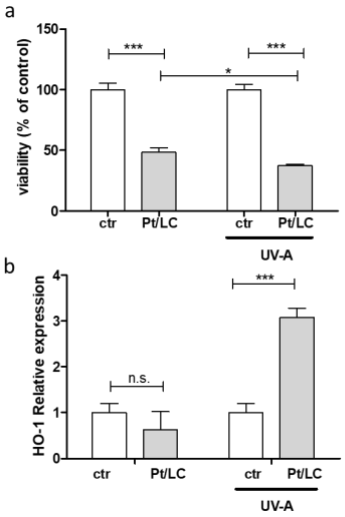

Figure 1: a) Cell viability and b) heme oxygenase-1 expression in A549 cell treated with Pt@LC NPs, with and without UV-A illumination.

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Efficient and Rapid Production of Bio-inspired Nanoparticles Derived from Bombyx mori Silkworm for Enhanced Breast Cancer Treatment

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Abstract:
In the quest for sustainable and biocompatible materials, silk fibroin, derived from natural silk, has emerged as a promising candidate for nanoparticle fabrication. This study focuses on opti-mizing the production process of silk fibroin nanoparticles (SFPs) by manipulating mixing kinetics and assessing the efficacy of a novel swirl mixer. The results demonstrate the superior performance of the swirl mixer, yielding SFPs with sizes below 200 nm and narrower size distributions (PDI: <0.20), in contrast to conventional methods. Notably, the rapid mixing facilitated by the swirl mixer enhances the encapsulation of magnetic nanoparticles and anti-cancer agents like curcumin (CUR) and 5-fluorouracil (5-FU). The therapeutic potential of bio-inspired curcu-min/5-fluorouracil-loaded magnetic core silk nanoparticles (CF-MSFPs) is evaluated across var-ious breast cancer cell lines and a murine breast cancer model, showcasing enhanced cellular uptake, sustained cytotoxic effects, and effective drug delivery. This study not only highlights the promise of the swirl mixer in tailoring CF-MSFP fabrication but also reveals that the swirl mixer excels in encapsulating both hydrophobic and hydrophilic drugs, exemplified by CUR and 5-FU. Importantly, our findings underscore the significance of using sustainable and bio-inspired ma-terials, ultimately advancing targeted drug delivery and breast cancer therapeutics to benefit pa-tient outcomes.

Keywords: silk fibroin; nanoparticles; sustainable materials; microfluidics; swirl mixer; magnetic nanoparticles; drug delivery system; curcumin; 5-fluorouracil; breast cancer

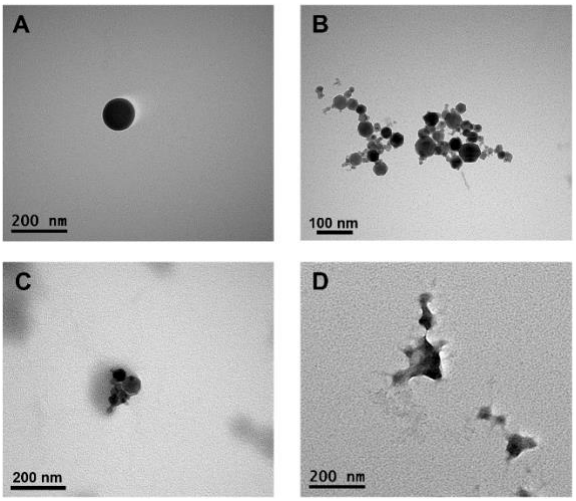

Figure 1: Transmission electron microscopy images of SFPs **(A)**, MNPs **(B)**, MSFPs **(C)**, and CUR/5FU-MSFPs **(D)** produced using microfluidics assisted desolvation by a novel swirl mixer.

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Microfluidic-mediated ZIF-Silk-Polydopamine Core-Shell Nanoparticles for Delivery of Zinc Ions and Curcumin in Breast Cancer Therapy

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Abstract:

Zeolitic imidazolate framework-8 (ZIF-8) as one of the most well-known Metal-organic frameworks (MOFs) has attracted a great deal of interest as a drug delivery vehicle for cancer therapy. However, the lack of controlled released behaviour of anti-cancer zinc ions largely limits its application as a therapeutic agent in cancer treatment. Herein, for the first time, we demonstrated microfluidic-mediated core-shell nanoparticles composed of ZIF-8 core, silk fibroin (SF) intermediate protection layer, and polydopamine (PDA) self-etching layer allowing a controlled release of zinc ions and curcumin (CUR) in breast cancer cells. The results show that the microfluidic-mediated method dramatically improves the rapid mixing during nanoprecipitation which could be used to precisely control the proportion of ZIF-8, SF, PDA, and CUR in the nanoparticles with a desired particle size (170 nm) and a narrow size distribution (PDI: 0.08). With a suitably coated SF intermediate protection layer, the capability of ZIF-8 as a zinc ions reservoir was efficiently improved from 20% to 58%. Moreover, in vitro study indicated that the PDA coating induced self-etching reaction naturally enabled a pH-responsive and sustained release of zinc ions and CUR in various breast cancer cells with a high cellular uptake efficiency and cytotoxicity but with minimum effect on non-cancer cells. Collectively, the as-prepared CUR@ZIF-SF-PDA nanoparticles can serve as ideal vehicles for the delivery of zinc ions and CUR in breast cancer therapy.

Keywords: microfluidic-assisted; ZIF-8; silk fibroin; polydopamine; curcumin; nanoparticles; controlled release; MDA-MB-231;

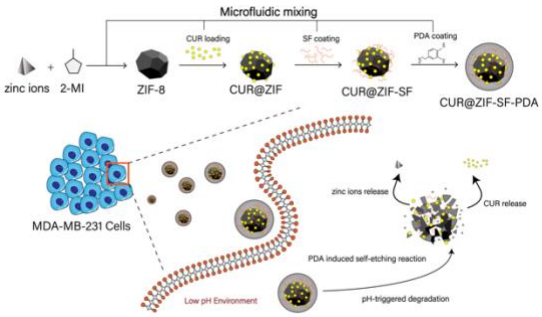

Figure 1: Synthetic scheme of ZIF-8-based nanoparticles through the microfluidic method.

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SMS / EGF 2022 Session III.A: Applications for energy and environment

Environmental Applications of Anodic TiO_2 Films for Water and Air Purification

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Abstract:
The interest in titanium and its oxides keeps growing on account of their peculiar engineered properties, which find applications in several fields, from architecture to bioengineering, from automotive to photovoltaic cells and photocatalytic devices. There are several methods that allow to grow titanium oxides, among which anodic oxidation has the nice advantage of growing TiO_2 nanostructures directly immobilized on a substrate, avoiding the issue of nanostructure recovery from the medium [1]. The experimental data here presented will then focus on latest achievements in the field of environmental cleanup with anodic TiO_2 oxides. Such materials are often tested in purification devices, for both wastewater and air treatment: the main goal is to achieve large surface area and high oxide crystallinity, in order to ensure the formation of oxides with high photocatalytic activity [2]. In this direction, the production of self-aligned TiO_2 nanotubes that stem vertically from the metal substrate (Fig. 1) is particularly attractive, as it allows to achieve specific surface areas even two orders of magnitude larger than the nominal one. Oxides are then tested in the degradation of organic dyes as representative of possible water contaminants, and in the degradation of volatile organic compounds (VOCs).
While dyes are often used to assess photocatalytic activity, typical tests are very far from real wastewater treatment, as they involve one single dye in distilled water; to better characterize the potential of these oxides, here we present the purification of multiple dye mixes and the influence on the process of possible ions present in water. On the other side, air purification was analyzed with a prototypal plug-flow reactor with different concentrations of toluene, representing medium-high pollution levels typical of an industrial context. Results indicate a good potential of these oxides in practical applications (Fig. 2), with a correct choice of the target environment.

Keywords: Photocatalysis, anodic oxidation, TiO_2, nanotubes, dyes, wastewater, air purification, VOCs.

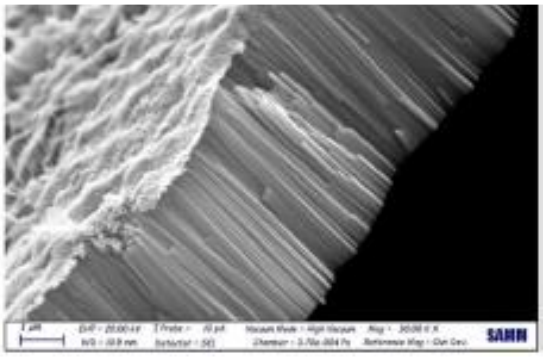

Figure 1: Morphology of nanotubular oxides employed in this work.

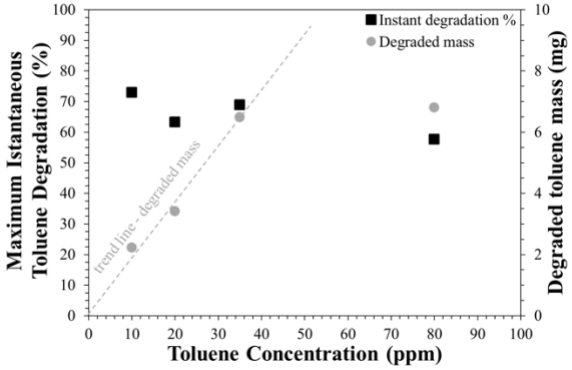

Figure 2: Toluene degradation extent (instant percent degradation and mass degraded in 30 min of test) as a function of inlet toluene concentration, in presence of 50% RH.

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Grafysorber® Technology
Innovative solution of oil recovery by emulsion treatment

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[2] Directa Plus SpA, Lomazzo , Italy; [3]Setcar , Braila, Romania

Abstract:
Emulsion and sludge treatments represent a very challenging activities in the oil industry. If successful they will lead to remarkable benefits and results.
The innovative Grafysorber® technology was awarded by the European Commission during the European Forum on Eco-Innovation 2015. This ecological product is obtained from natural graphite through a patented process. It rapidly adsorbs any type, hydrocarbon and organic pollutants from water and soil.
Grafysorber® technology reduces environmental and HSE impacts and generates financial benefits by:

- Recovering oil from sludge or emulsions
- Reducing the impact of oil spills
- Reducing process waste
- Reducing usage of toxic chemicals
- Providing a simple solution for minimizing storage space

The technology was presented to OMV Petrom SA during the Eco-Innovation Forum 2017, and successfully qualified for field-testing.
During 2017 and 2018 the project went through two test phases for:
• improving the quality of water (reducing oil concentration below 5 ppm) obtained from first separation, to be used in the injection process.
• recovering oil from emulsion and sludge without additional treatments.
Both phases were successfully finalized and in addition, adsorbent pillows and booms with Grafysorber® were tested. This test proved easily and quickly the containment capacity of Grafysober® for oil spills.
Due to successful pilot, the program was expanded and improved via new technology programs of OMV Petrom S.A. and Grafysorber® technology was tested on a larger scale with impressive achievements.
• treated in average 84 m3 of emulsion daily, resulting in 19 tons of oil recovered (equivalent to a high production oil well in a mature field with only stripper wells)
• processed in total approx. 40,000 m3 of emulsion and more than 10,000 tons of oil recovered until today, also significantly freeing up tank storage capacity.
• fulfilled the sales specifications (BSW < 1%) with the recovered oil in a continuous process over 14 months, thereby increasing oil delivery and revenues.
This paper will describe the daily process, monitoring, observations, learnings, improvements, and achievements for the period 2020-2022, as well as the economic impact and way forward.
The benefits of the technology include:
• the possibility to recover almost completely the crude oil in emulsions and sludges;
• the versatility of Grafysorber®, suitable for both, treating production by-products (emulsions) or wastes (sludges) and for improving injection water quality, eliminating hydrocarbon residues;
• the possibility of exploiting the absorbent capacities of Grafysorber® using it inside booms and pillows for oil spills prevention.
Grafysorber® technology represents a vanguard solution to the historical problem of emulsion. It is non-toxic, sustainable and generates new profits-briefly defined as “the dragon which is fed with emulsion and spits crude oil”.

Keywords: Grafysorber, emulsion, sludge, treatment, oil recovery, technology, adsorbent,oil spills, water quality, barriers, pillows.

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Thermal analysis of magnesium hydride

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Abstract:
Global transportation is gradually shifting towards electric power, yet marine transportation is trailing behind in terms of implementing sustainability solutions in a timely manner. Fully electric alternatives for long distance shipping are economically impracticable and with other alternatives being unavailable and considering that the marine transportation sector, albeit being industrially vital, contributes considerably to the global emission of pollutant gas. Hence the research for solutions to increase the ecological efficiency of intercontinental cargo ships. One of such pursuits is modifying the hull to reduce hydrodynamic drag [1], and such modifications can be achieved by architectural design changes or implementing surface coatings. In this work, thermal analysis of magnesium hydride coatings is conducted in order to ascertain its viability as a coating material suitable to facilitate hydrodynamic drag reduction. Due to the tendency of MgH_2 (Figure 1) to release hydrogen at higher temperatures or during reaction with water, it is expected to contribute to sustaining Leidenfrost effect [2]. Samples sourced from industrial suppliers and prepared in situ via reactive magnetron sputtering were submitted to thermal analysis, using Netzsch STA 449 F3 Jupiter thermal analyzer, coupled to Bruker Tensor 27 FTIR spectroscope. The surface characterization was performed using X-Ray diffraction test. The obtained results are expected to shed light on the application potential of magnesium hydride coatings as active surface material for the express purpose of generating a steam film, resulting in hydrodynamic drag reduction for large scale marine vessels.

Keywords: TGA, vapour film, Leidenfrost effect, thermal stability, surfaces.

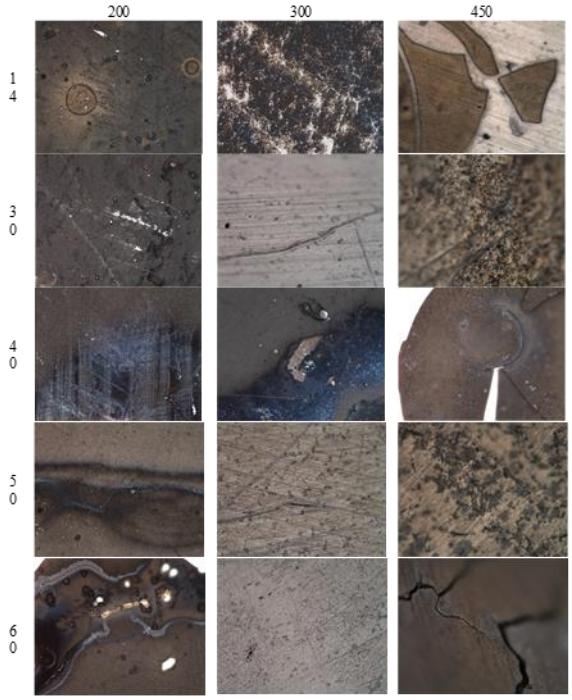

Figure 1: Microscopy images of magnesium hydride samples. X100 optical magnification. Columns display sample temperature (°C), whereas rows display water temperature (°C).

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Elucidating the Trajectory of the Charge Transfer Mechanism and Recombination Process of Hybrid Perovskite Solar Cells

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Abstract:
Perovskite-based solar cells (PSCs) have attracted intense interest in solar cell research since their inception in 2009. To optimize the performance of hybrid perovskite cells, a primary and crucial strategy is to unravel the contact materials' dominant charge transport mechanisms and interfacial properties. This study focused on the charge transfer process and interfacial recombination within the n–i–p architecture of solar cell devices. The motivation for this paper was to investigate the impacts of recombination mechanisms that exist within the interface in order to quantify their effects on cell performance and stability. To achieve our objectives, we first provided a rationale for the photoluminescence and UV-Vis measurements on perovskite thin film to allow for disentangling of different recombination pathways. Secondly, we used the ideality factor and impedance spectroscopy measurements to investigate the recombination mechanisms in the device. Our findings suggest that charge loss in PSCs is dependent mainly on the configuration of the cells and layer morphology, and hardly on the material preparation of the perovskite itself. This was deduced from individual analyses of the perovskite film and device, which suggest that major recombination most likely occurs at the interface.

Keywords: interface; recombination; ideality factor; perovskite solar cell

A Novel $MgFe_2O_4/Bi_4O_5Br_2$ Heterojunction Photocatalyst with Enhanced Photocatalytic Activity for Degradation of Bisphenol A and Reduction of Cr(VI) under Visible light

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Abstract:
Fabrication of a heterojunction photocatalyst with suitable band structures is considered to be an effective strategy to enhance the photocatalytic efficiency by reducing a high recombination rate of photogenerated carriers and enhancing the redox ability of the photocatalyst [1]. In this work, a direct Z-scheme $MgFe_2O_4/Bi_4O_5Br_2$ heterojunction was fabricated by wet impregnation. Herein, $MgFe_2O_4$ and $Bi_4O_5Br_2$ were separately synthesized by solvothermal and microwave irradiation methods, respectively. Weight percentages (%wt) of $MgFe_2O_4$ (0.5, 1, 3, 5, 7%wt) in the $MgFe_2O_4/Bi_4O_5Br_2$ heterojunctions were optimized to obtain high photocatalytic activity for photodegradation of bisphenol A (BPA) and hexavalent chromium ion (Cr(VI)) under visible light irradiation. Morphological studies revealed that the uniform $MgFe_2O_4$ nanospheres were homogeneously deposited on flower-like $Bi_4O_5Br_2$ microspheres. Characterized by UV-Vis DRS, visible light responsibility of the $MgFe_2O_4/Bi_4O_5Br_2$ heterojunctions was enhanced when compared to $Bi_4O_5Br_2$. Among the as-prepared samples, the $MgFe_2O_4/Bi_4O_5Br_2$ photocatalysts with 1%wt of $MgFe_2O_4$ provided the highest photodegradation efficiency of BPA; 87.1% of 10 mg L^{-1} BPA and 75.2% of 30 mg L^{-1} BPA were degraded after being irradiated for 360 min. This photocatalyst also reduced 92.2% of 20 mg L^{-1} Cr(VI) solution at pH solution of 3. Electrochemical measurements demonstrated the efficient separation and migration of charge carriers in the 1%wt-$MgFe_2O_4/Bi_4O_5Br_2$ heterojunction which were responsible for enhanced photocatalytic activity. The 1%wt-$MgFe_2O_4/Bi_4O_5Br_2$ heterojunction generated holes, superoxide and hydroxyl radicals through Z-scheme charge transfer mechanism. This work provides the development of visible-light driven photocatalysts with Z-scheme photocatalytic pathway for solving environmental pollutants problems.

Keywords: $MgFe_2O_4/Bi_4O_5Br_2$, heterojunction, Z-scheme, Photocatalytic activity, Visible light

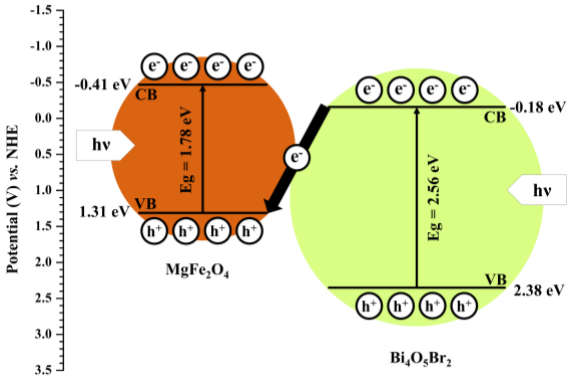

Figure 1: Schematic diagrams for energy bands of $MgFe_2O_4$ and $Bi_4O_5Br_2$ and a Z-scheme charges transfer machanism for enhanced BPA photodegradation and Cr(VI) photoreduction.

References:

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NanoMed / Sensors 2023 Session III.B

DNA Conformational Changes Induced by Its Interaction with Platinum Complexes in Solution. Comparison of Platinum, Ruthenium and Cadmium compounds

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Abstract:
Platinum anticancer drugs inhibit the division of cancer cells through a DNA binding mechanism. The bimetallic platinum compounds have a possibility for blocking DNA replication via the cross-linking of DNA functional groups at different distances. Many compounds with metals of the platinum group have been tested for possible antitumor activity. The main target of their biological action is a DNA molecule. A combined approach to the study of the interaction of DNA with biologically active compounds of this type is proposed. The capabilities of various methods (hydrodynamic, spectral, microscopy) in obtaining information on the type of binding of coordination compounds to DNA are compared. The analysis of DNA binding with platinum binuclear compounds containing pyrazine, tetrazole, 5- methyltetrazole, 3-propanediamine as bridging ligands in a solution was carried out with the methods of circular dichroism (CD), luminescent spectroscopy (LS), low gradient viscometry (LGV), flow birefringence (FB) and atomic force microscopy (AFM). The competitive binding of different platinum compounds to DNA and the analysis of platinum attachment to DNA after protonation of its nitrogen bases simply indicates the involvement of N7 guanine in binding. Fluorescent dye DAPI was also used to recognize the location of platinum compounds in DNA grooves. DNA conformational changes recorded by variations in persistent length, polyelectrolyte swelling, DNA secondary structure, and its stability clarify the molecular mechanism of the biological activity of platinum compounds. Ruthenium and Cadmium compounds were also regarded.

Keywords: DNA-platinum complexes; binuclear platinum (II) compounds; pyrazine; tetrazole; 1,3-propanediamine

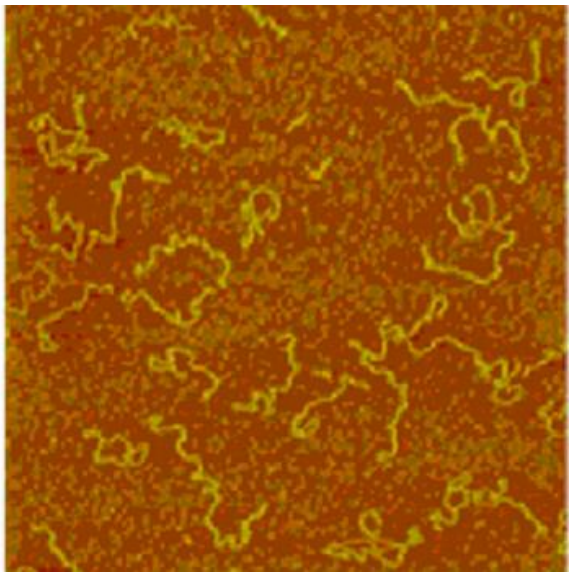

Figure 1: Double-stranded DNA kinks induced by cisplatin binding

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Printed Sensors, Biosensors and Actuators
Current and future trends for Point-of-Need applications

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Abstract:
In recent years, there has been a significant drive to develop innovative sensors tailored for Point-of-Need applications, with the aim to provide reliable multi-target and scalable solutions. Point-of-Need devices have caused a huge impact on different fields such as environmental monitoring, forensics, the food industry and the healthcare, where they have become indispensable for the onsite and rapid analyte detection. The features of the new platforms that have to be designed are usually described under the acronym of REASSURED ((R) real-time connectivity,(E) ease of specimen collection, (A) Affordable, (SS) Sensitive and Specific, (U) User-friendly, (R) Rapid and Robust (E) Equipment-free, (D) Delivered to end-users)[1].
Printing techniques have opened up new avenues for crafting smaller and more adaptable products, compatible with cost-efficient mass production. The recent integration of these techniques has driven substantial advancements[2]. Nonetheless, emergent technologies like printed sensors and actuators face a crucial challenge, effectively dealing with ambient interferences through real-time and in-situ data collection on a specific location from medical to environmental applications. Such challenge demands innovative approaches that balance scientific research with design principles, laying the foundation for the seamless adoption of future solutions. In this presentation, we delve into the roadmap of printed sensors, biosensors and actuators, exploring their potential for Point-of-Need solutions through the lens of various illustrative use cases. We will outline the evolution of sensors' development using printing technologies. Our focus will be on design, detection methods and fabrication methodologies, all based in scalable automated printing techniques such as screen-printing, inkjet-printing and spray-coating.

Keywords: printed electronics, printed sensors, biosensors**,** actuators, multiparametric platforms, Point-of-Need, Point-of-Care connectivity.

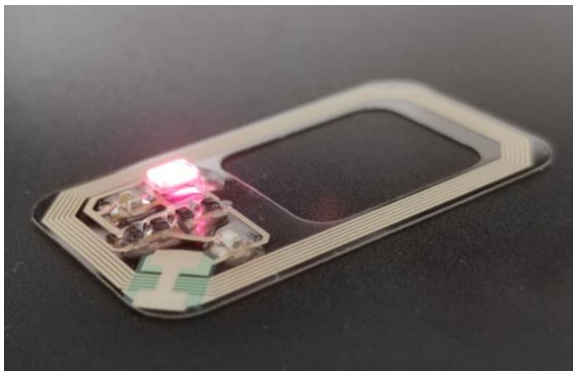

Figure 1: Image of the wireless-powered printed electronic circuit for the Optogenerapy implant, based on optogenetics for the treatment of Multiple Sclerosis treatment[3].

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Industrial Measurements, Communications and Protocols

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Abstract:
Industrial measurements and protocols have specific demands that have been evolving over the time. There are a large number of specialized documentations that describes in detail the evolution registered in these areas. However, a global and integrated vision of the main steps that were registered in the evolution of industrial measurement and communication protocols is oftentimes missing.
This presentation pretends to make a link between the past and the future of Industrial Measurements, Communications and Protocols, and includes two main parts. The first part focuses several topics that are related with the measurement of electrical and non-electrical quantities and the second part includes a summary of the main protocols that are used in instrumentation and control (I&C) networks. In the end of the presentation, the audience should understand the main challenges associated with industrial measurement, identify the main characteristics of I&C protocols that are used in industrial networks, as well as, the requirements that must be considered to choose the right instrumentation and measurement solution, in terms of performance and cost, for a specific industrial measurement application.
In the first part of the presentation several concerns related with industrial measurements are underlined. It can be said that industrial measurement problems start, themselves, in the specificities of the quantities that are under measurement. Almost all industrial quantities are affected by multiple influence variables whose variations, over time, must be accounted in order to obtain metrological comparability and traceability of measurement results. Suitable data processing techniques must be used to identify the main influence variables, that affect the measurement result of a given quantity, and to evaluate the associated compensation coefficients in order to convert the measurements results to a predefined influence variables values, usually called as reference values.
Sensor selectivity is also a problem that must be properly addressed because the output signal from a sensor is always affected by other variables that are not under measurement. This problem has a particular relevance in chemical and biological sensors and sensor selectivity can compromise significantly measurement accuracy. This drawback can be minimized by using multiple sensing devices, with different measurement principles, that assure different cross-sensitivity coefficients, or by using *intelligent* data processing techniques, like the ones based on artificial neural networks.
It is also important to refer that smart sensing capabilities, including adaptability, self-testing, self-calibration, auto-ranging and errors correction capabilities, among others, contribute to improve the accuracy and the performance of industrial measurement systems and to promote interoperability of sensing units and industrial devices. Implementation of these capabilities in industrial instruments, from different manufacturers, is very important, regarding instrumentation and measurement solutions for industrial applications, since it promotes devices interoperability and consequently cost reduction in maintenance and operation of I&C systems.
Regarding reliability and performance of industrial systems, some issues related with noise immunity are addressed. Shielding and grounding techniques to reduce conductive, inductive, capacitive and electromagnetic energy coupling, can have a huge negative impact in industrial system's reliability and performance. Often, a very accurate and expensive measurement instrument is not the best choice in noisy industrial environments, being its reliability and robustness much more important issues.
A few words are also dedicated to the real time requirements and events' synchronization, in distributed control systems (DCS). A classification of real time requirements according to I&C timing demands is briefly presented.
It is important to refer that security and safety issues are also very important topics, especially in industrial hazards areas that exhibit fire, explosion, toxic release and environmental damage risks. However, a detailed approach of these important topics is out of scope of the presentation.
In the second part of the presentation a survey of industrial communication protocols, from current loops to fieldbuses, is presented and their main advantages and limitations are underlined. The survey starts from the need to define standardized levels in pneumatic and electrical signals, and continues towards more advanced protocols, such as, highway addressable remote transducers (H.A.R.T.), wireless H.A.R.T. and fieldbuses.
Results obtained from a developed Foundation Fieldbus (FF) prototype are used to illustrate some characteristics of fieldbus protocols.
Concerning industrial wireless networks, a brief reference to the model predictive control (MPC) is performed since it can be required to use simulated measurement data when wireless transmission failures occur, or when measurements are available at irregular periods of time or at a much slower update rate than the one required by the control algorithms (PIDPlus).
In the last part of the presentation a brief summary of future development directions of industrial networks and protocols, that can support demands associated with Industry 4.0 and Industrial Internet of the Things (IIoT), is performed.
Usage of industrial IoT, together with advanced processing tools (Big Data), will give access to a huge quantity of measurements, enabling the find out of hidden information that can be gathered from data analysis, leading to reductions in systems' engineering, maintenance and operation costs.

Electrochemical Impedance Spectroscopy as a tool for discovering antimicrobial agents from environmental sources

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Abstract:
The increased resistance to antimicrobial therapy has risen alarmingly over the past years, being an ever-growing threat to public health [1]. The need for discovering new antimicrobial agents along with developing novel tools and methodologies for their identification is of outmost relevance. Considering the high degree of diversity and high load of microorganisms posing resistance genes in waste sources [2, 3], this is a potential source of unidentified bioactive metabolites. Therefore, within the multi-institute project ABC Health (Anti-Bacterial Channelling from waste to human health) we aim at developing new tools for detecting novel antimicrobials. These tools include polymeric substrates that can be tailor-made to support biofilm formation for efficient screening [4], and an electrochemical impedance spectroscopy (EIS) sensor system for monitoring biofilm growth and its disruption by samples with antibacterial activity.
To develop the EIS sensor, validation of the approach was initially done with Staphylococcus aureus cultures being treated with varying concentrations of antibiotics scrutinizing differences between treated and untreated biofilms. Based on the bacterial biofilm responses, equivalent circuit modelling is attempted. Since electrodes for the EIS sensor can be printed on almost any material, it enables flexible, low-cost and sustainable solutions for large-scale screening. Next, wastewater samples (i.e., activated sludge) were explored in order to identify antibacterial-active sites, which will be further probed for their prospect as unique antimicrobial metabolites.

Keywords: Electrochemical impedance spectroscopy, Staphylococcus aureus, antibiotics, drug discovery, drug response.

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Synergistic Influence of Static Magnetic Field and Magnetite-nanoparticles on a Microbial Fuel Cell in Anaerobic Digestion

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Abstract:
The selectivity of catalytic substance appropriate for oxygen reduction reaction of microbial fuel cells (MFCs) is extremely significant. Thus, exploring the synergy of static magnetic field and magnetite-nanoparticles as another alternative to enhance interspecies electron transfer (IET) proves useful. This work was aimed at investigating the synergistic influence of static magnetic field and magnetite-nanoparticles on an MFC in anaerobic digestion. The experiments were carried out by means of four 1 L digesters: i) control, ii) an MFC, iii) an MFC with magnetite-nanoparticles as additives (MFCM), and iv) an MFC with magnetite-nanoparticles and magnet (MFCMM). The addition of magnetite-nanoparticles on a MFC showed biogas improvement of 68.7% over the MFC digester. The use of static magnetic field on a MFC (MFCMM) revealed even higher biogas production of 545.2 mL/g VS_{fed} over the 117.7 mL/g VS_{fed} of the control. Results of electrochemical efficiencies showed higher coulombic efficiency (94.4%) and electrical conductivity (1480.0 µS/cm) for the MFCMM. This was accompanied by higher percentage decontamination for total solids (TS) of 97.4%, chemical oxygen demand (COD) of 97.3%, volatile solids (VS) of 96.1%, total suspended solids (TSS) of 88.7%, and color of 70.2%. In terms of kinetic analysis, the cumulative biogas data acquired were well-fitted on the modified Gompertz models and the MFCMM digester showed the highest coefficient of determination, i.e., $R^2 = 0.990$. All in all, the synergy of static magnetic field and magnetite-nanoparticles on an MFC revealed a greater potential for biogas generation and decontamination for wastewater treatment.

Keywords: static magnetic field, magnetite-nanoparticles, anaerobic digestion, microbial fuel cell, biogas production, kinetic analysis, electrochemical efficiencies, decontamination.

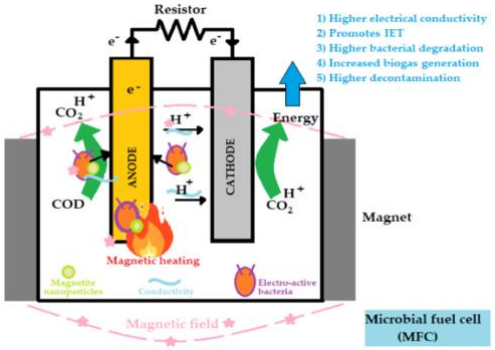

Figure 1 (Graphical abstract): The IET pathway between microorganisms and Archaea is the key to greater conversion of organic matter to carbon dioxide, which leads to greater energy produced by the MFC digester. The current article finds that the synergy of static magnetic field and magnetite-nanoparticles on an MFC in the anaerobic digestion process improves both magnetic field and electrical conductivity, which reduces the opposition that ions and the H^+ protons encounter as they migrate from the anode to the cathode of an MFC. This promotes the IET pathway, which leads to greater microbial degradation, decontamination, and biogas production.

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A Laser Modulation-based Fiber-Optic Fabry-Perot Interferometer for High Precision Pulse Wave Monitoring

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Abstract:
In this work, a fiber-optic Fabry-Perot interferometer (FFPI) has been investigated for continuous pulse wave monitoring. The interferometer exploits a laser modulation technique to multiplex input optical wavelength, generating 2 in-quadrature waves of sine and cosine. After signal optimization and phase shift demodulation, displacement information of human pulse wave can then be obtained in quasi-real time. Here, a designed FFPI-based pulse probe is firstly investigated for its sensing capability using a piezoelectric actuator. Pulse wave monitoring on human participants are, subsequently, conducted simultaneously with a reference sphygmomanometer, according to Fig. 1(a). The former experiment revealed the FFPI's precision of 1.3199 nm at 30 µm/s of target velocity, implying its highly precise movement detection. Meanwhile, interferograms due to arterial distension (shown in Fig. 1(b)) are successfully demodulated into clearly defined pulse waves, seen in Fig. 1(c). Furthermore, 11 repeatable heart rate measurement on the participants yield a mean error and standard deviation of -1.09 ± 0.94 beats per minutes, respectively, which is within the accuracy range of the reference device. Therefore, we concluded the proposed FFPI has high precision in human pulse wave monitoring and can be further developed into a novel continuous blood pressure measuring instrument for future biomedical applications.

Keywords: fiber optic sensors, fiber-optic Fabry-Perot interferometer, pulse wave monitoring, heart rate measurement, non-invasive blood pressure monitoring.

Acknowledgment
This research is funded by the Royal Golden Jubilee (RGJ) Ph.D. programme, National Research Council of Thailand under grant no. PHD/0189/2561.

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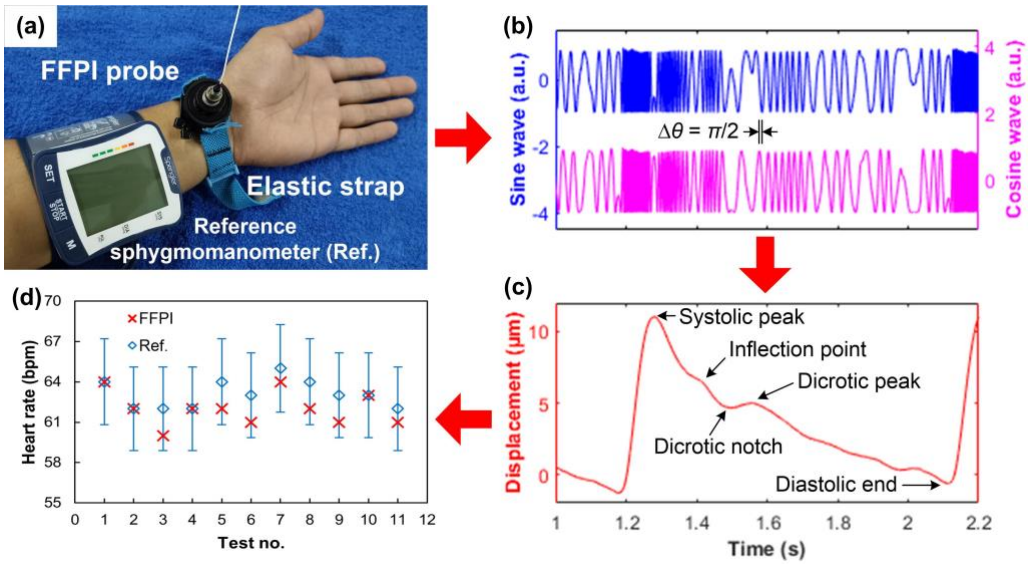

Figure 1: Pulse wave monitoring using a designed FFPI probe; (a) setup on a human participant, (b) interferograms from pulse monitoring, (c) demodulated pulse wave with clearly defined characteristics, (d) summarized heart rate measurement results

of central arterial pulse waves, *Hypertens. Res.*, 41(11), 904-912.

Posters Abstracts

Laser-Induced Graphene on Sodium Alginate

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Abstract:
In 2014 it was discovered that 3D porous graphene can be produced by irradiating polyimide (PI) films with a CO_2 laser under ambient conditions[1]. Graphene made with this method possesses interesting properties, such as a high surface-area-to-volume ratio, mechanical and thermal stability and good conductivity[2]. This straightforward fabrication approach is easily accessible, since it does not require expensive tools, special ambient conditions or post-fabrication treatment. In recent years, the range of precursor materials for laser-induced graphene (LIG) production has been expanded to substrates different from PI[2]. Multiple synthetic polymers and naturally occurring materials have been explored as precursors. It would be interesting, however, to induce graphene on bio compounds, which are widely available, ecological and biocompatible. Sodium alginate (SA), derived from seaweed, is a promising carbon-rich material for LIG. SA is non-toxic, biodegradable, biocompatible, and cost-effective[3]. Despite its favorable properties and widespread applications in biomedicine, SA has never been used as a precursor for laser induction of graphene. We demonstrate the production of LIG on SA hydrogel. Additionally, we describe the optimization of laser parameters for LIG production, including power, speed and scanning resolution. Furthermore, we conduct physicochemical characterization of the resulting LIG, with Raman spectroscopy, scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDX), X-ray diffraction (XRD), transmission electron microscopy (TEM) and Fourier transform infrared spectroscopy (FTIR). All methods demonstrate formation of graphene on the surface of SA. LIG on SA has potential applications in bioelectronics, including medical wearables.

Keywords: laser-induced graphene, sodium alginate, polymers, bioelectronics, wearables

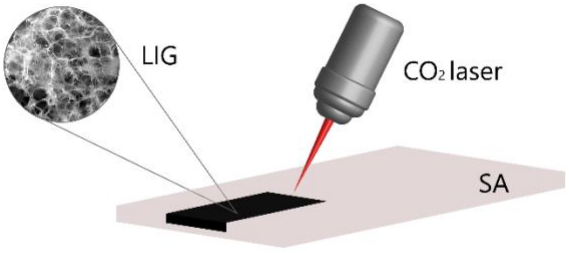

Figure 1: Graphene induction onto a sodium alginate precursor with a carbon dioxide laser.

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Wettability characteristics of Al-6061 alloy surface generated using high frequency Longitudinal Vibration assisted end-milling

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Abstract:
The wettability characteristics of micro-textured Al-6061 alloy is evaluated. High frequency Longitudinal ultrasonic vibration assisted milling (LUVAM) method has been used to machined the Al-6061 alloy surface at different feed rate values while all the other machining parameters remain constant. As compared to the conventional milling method LUVAM offers distinct advantages such as lower cutting forces, enhanced tool life and better surface quality [1]. Moreover, with LUVAM method it is possible to create micro textures on the machined surface which aids in enhancing the wettability and tribological properties [2]. The LUVAM method has a vibration frequency of 40.4 kHz, having a peak-to-peak vibration amplitude of 1.2 µm at an input voltage of 100 V. The low vibration amplitude creates the micro-structure on the machined surface as shown in Fig. 1. A professional equilibirum water contact angle measuring machine, known as goniometer, has been used to measure the water contact angle on the surface. The volume of each water droplet has been set at 10 µl during the wettability analysis. The introduction of micro-textures on the machined surface increases the water contact angle as the feed rate value increases during the LUVAM method. i.e. the surface become hydrophobic in nature. In case of conventional milling method, an exact opposite phenomenon will be observed. The machined surface become hydrophilic with the increase in feed rate, i.e. the water contact angle decreases.

Keywords: Longitudinal Ultrasonic Vibration Assisted Milling, Surface texture, Wettability analysis, Goniometer, Hydrophobic surface, water contact angle.

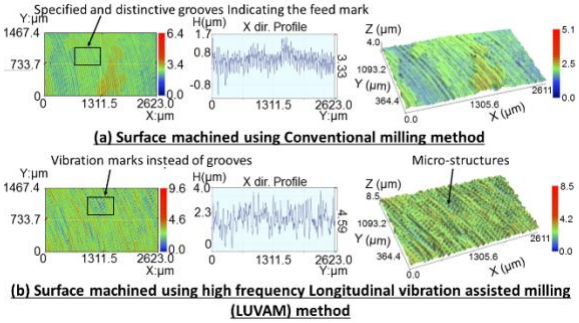

Figure 1: Surface morphology of machined surfaces

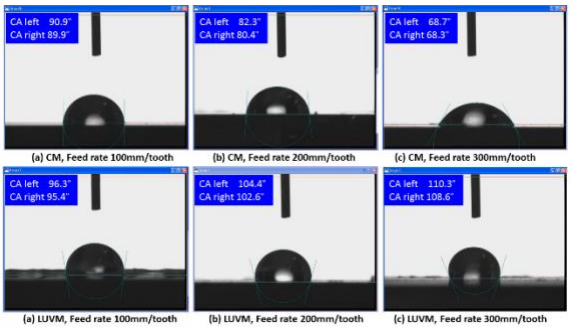

Figure 2: Wettability analysis

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Multifunctional Microstructured Surfaces using Microcontact Printing of Microgels

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Abstract:
Surface modification is an important tool to tailor the properties of materials and is commonly applied to facilitate the design of complex systems for use in biomedicine or electronics. The implementation of reactive microgels for surface modification enables the incorporation of multiple tunable functionalities at once. Such modified surfaces offer a variety of applications in the field of life sciences. In particular, microgel-decorated substrates can be useful to study the influence of different chemical and topological cues on adhesion, motility and proliferation of cells.[1,2]
The present work combines surface structuring techniques with reactive (post-)modification to design complex interfaces providing structural, chemical and mechanical cues on the basis of poly(*N*-Vinylcaprolactam) microgels decorated with reactive groups. Soft lithography techniques were employed to design micrometer-sized line patterns on glass surfaces. The successful transfer of the printed pattern for microgels with varying chemical composition was proven by light and atomic force microscopy.
Reactive moieties, such as epoxy or amine groups, incorporated in the microgels enable anchoring to functional surfaces. Covalent coupling of reactive fluorescent dyes to printed microgel arrays was performed to demonstrate the possibility of chemical modification. The fabrication of surface chemical gradients *via* dip-coating demonstrate the suitability for various life-science applications. Furthermore, multi-layer microgel arrays could be generated by using two different reactive microgel types.

Keywords: micropatterning, microgel, surface functionalization, biomedical applications

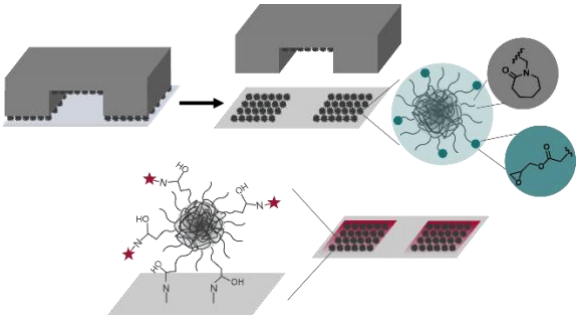

Figure 1: Combination of soft lithography and click chemistry allow for the design of stable micro-patterned microgel-modified substrates with surface-chemical gradients.

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Optical and mechanical properties assessment for the main sol-gel ZrO_2 coatings in CSP plants

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Abstract:

In recent years, the interest in molten salts as heat transfer fluids and thermal storage media in concentrated solar power (CSP) plants has increased[1]. This is mainly due to their excellent properties: high specific heat, high density, low melting point and high thermal stability, as well as a competitive price. However, using this type of heat transfer fluid also manifests serious corrosion problems in the CSP plant's metallic elements[2]. At this point, sol-gel ceramic coatings are presented as one of the best passive protection methods to combat this problem[3]. In this study, the analysis and characterisation of different sol-gel solutions based on ZrO_2 and doped with different molar proportions of Y_2O_3 (3, 9 and 12 mol%) has been carried out. Thus, besides guaranteeing the correct corrosion performance of the main multilayer sol-gel coating types in CSP plants, their mechanical and optical properties have been studied and characterised. The results show similar corrosion performances for the three types of coatings. However, significant differences are observed in the optical and mechanical properties. Therefore, as the dopant Y_2O_3 increases, the refractive index (n) increases, while the absorption (α) and extinction (κ) coefficients, the hardness (H) and the elastic modulus (E) decrease. The observed trends are of particular relevance in CSP plants and systems, where strict conditions for reflection and absorption of light energy are required; while maintaining optimal mechanical properties.

Keywords: Optical properties, Mechanical properties, Concentrated Solar Power (CSP), Sol-gel, Coatings.

Figure 1: CSP Plant and key metallic components. (Available at: https://n9.cl/duf9w)

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CrSi-based carbo-nitrides protective coatings for industrial woodworking applications

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Abstract:
The aim of the study was to enhance the quality of cutting tools used in wood industry, where working parts and tools are subjected to severe conditions. CrSi-based carbo-nitrides were deposited by cathodic arc evaporation using CrSi cathodes with 99.9% purity using different flow rates of high purity acetylene gas (C_2H_2; 30, 50 or 70 sccm) and different flow rates of high purity nitrogen (N2; 70, 50 or 30 sccm) into the deposition chamber. A deposition time of 40 min chosen, for a final thickness of approximately 1 µm. The substates are made of stainless steel similar to those used in industrial woodworking applications and polished to a roughness of 50 nm.
Tribological characteristics were investigated and surface morphology, elemental/phase composition was evaluated before and after corrosion process. The results showed that CrSiCN coatings can improve the corrosion resistance of the uncoated steels. Moreover, an increase in the carbon content led to a positive influence on their electrochemical behaviour, whatever was the type of substrate.
The main purpose was to improve the wear and corrosion resistance of the studied samples and to select the optimal parameters for producing coatings with excellent properties for coating of tools used industrial woodworking applications.
Acknowledgment: This research was funded by a grant of the Romanian National Authority for Scientific Research and Innovation, CCCDI – UEFISCDI, project number COFUND-M-ERANET-3-HardCoat-1, no. 311/2022, within PNCDI III, and by the Romanian Ministry of Research, Innovation and Digitalization through the National Plan of Research, Development and Innovation 2022-2027, Core Program, Project no: PN 23 05, Contract no: PN11N-03-01-2023, and through Program 1- Development of the National Research-Development system, Subprogram 1.2 - Institutional Performance - Projects to Finance the Excellent RDI, Contract no. 18PFE/30.12.2021.

Keywords: corrosion resistance, protective coatings, carbonitrides

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Contribution of Nanoparticles of Mixed Oxides Derived from LDH in the Crystallization of Cement Phases During Hydration

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Abstract:
Lamellar double hydroxides (LDH) are a class of multifunctional additives that can contribute to the control of the microstructure of hydrated cement. The thermal decomposition of LDH at moderate temperatures (400°C) leads to the formation of nanocrystalline mixed oxides (MO), such as $M^{2+}O$, $M^{3+}{}_2O_3$ and $M^{2+}M^{3+}{}_2O_4$, in variable proportions, depending on the composition, heating rate and atmosphere. These MO can regenerate the lamellar structure in contact with water and anionic solutions, through the memory effect.[1] The regeneration of the LDH lamellar structure directly influences the rheological behavior of the cement paste, with the acceleration of paste consolidation during the first hours, which indicates the potential of MO as additives for 3D printing.[2] Changes in rheological properties are associated with the regeneration mechanism of the HDL structure concomitant with cement hydration. The results obtained in situ using the time-resolved X-ray absorption spectroscopy (XAS) technique demonstrated that the recovery of the ZnGa–HDL nanostructure occurred by a mechanism of nucleation and aggregative growth. In a simulated concrete pores solution (SCPS, pH 14) the formation of the HDL phase was verified, followed by the dissolution in oxides of component metals such as ZnO. In addition to the memory effect, the considerable surface area (~37 m^2g^{-1}) of OM particles may favor heterogeneous nucleation, contributing to the strengthening of the hydrated cement microstructure. To increase the understanding of the role of MO in these phenomena, the formation of hydration phases was monitored in situ by X-ray diffraction (XRD) for the cement paste containing ZnGa-LDH and the respective MO during 4 h after the first contact with water. The results showed acceleration of the hydration process, evidenced by the increase in the formation of the ettringite phase (AFt), mainly for the sample containing MO. It indicates that the regeneration of the HDL structure favors the kinetics of crystallization of AFt. Furthermore, during aging AFt is converted into hydrated calcium monosulfoaluminate (AFm), which has a layered structure similar to that observed in hydrotalcite-type compounds. Thus, the results obtained allowed correlating the effect of MO nanoparticles on the crystallization of the hydration phases with the structural changes of the cement.

Keywords: LDH memory effect, lamellar structure, nanoadditives, cement hydration.

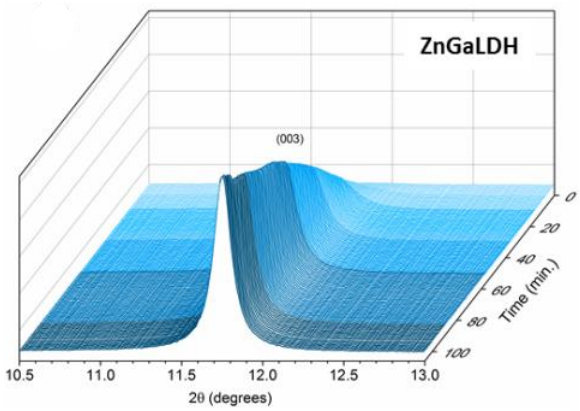

Figure 1: XRD monitoring of the RT recovery of the LDH after SCPS addtition to the MO

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Acknowledgements
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The Relevance of Iron Distribution in Smectite Clays on the Improvement of the Thermostability of PMMA-Clay Nanocomposites

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Abstract:
Polymer-Clay nanocomposites present improved thermostability as compared to the polymer matrix. The physical barrier induced by the inclusion of 2D clay nanoparticles and radical trapping assisted by the distribution of selected 3d atoms in the inorganic phase are responsible for these emergent properties[1,2]. Aiming to unravel the relevance of the Fe^{3+} distribution on this synergic effect, the iron ions in solid solution in Nontronite (Non, Fe 5.6 wt.%) or in Maghemite (γ-Fe_2O_3) nanoparticles were incorporated to nanocomposites formed by Poly(methyl methacrylate) (PMMA) and smectite clay. The Na-Laponite (Lap) was used to evaluate the contribution of the diffusion barrier effect on the increase of the thermostability of PMMA/Lap nanocomposite, proved by the upshift of thermogravimetric (TG) curve as respect to PMMA. The contribution of the radical trapping on the thermostability of nanocomposite was evidenced by the significant shift of the rising edge position by -7.0 eV experienced by iron reduction upon heating under N_2 for PMMA-Non, as soon as similar treatment of pristine Nontronite does not lead to rising edge shift in X-ray absorption spectra (XAS). This downshift demonstrated the reduction of Fe^{3+} to Fe^0 species induced by the sequestration of radicals formed by the PMMA depolymerization. The PMMA-M-Lap nanocomposite owes its improving in thermostability also to the combined contribution of the gas diffusion barrier effect and radical trapping by the iron atoms up to about 410 °C. Above 410 °C, only radical trapping by iron is responsible for the further stabilization of the nanocomposite. Maghemite effectively captures the radicals confined by the layered clay causing a significant stabilization of the nanocomposite with a significant shift in the mass loss of the PMMA-M-Lap nanocomposite compared to PMMA-Lap. In addition, during the heating of the PMMA-M-Lap nanocomposite the following transformations occur: γ-Fe_2O_3 ⇒ Fe_3O_4 ⇒ FeO, allowing to a mixture of magnetite and wustite at 550 °C. Raman spectroscopy evidenced the formation of char deposits above 400°C, which contributes to the stability of remaining PMMA up to 500°C though additional physical barrier to the mass transport.

Keywords: Nanocomposites, Poly(methyl methacrylate), Clay, XAS, TG.

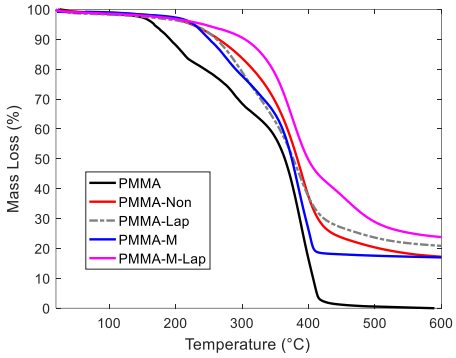

Figure 1: TG curves PMMA-Non, PMMA-Lap, PPMA-M and PMMA-M-Lap nanocomposites and the pristine PMMA.

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Acknowledgements:
Authors thank the financial support received from the Brazilian agencies FAPESP, CAPES, and CNPq.

On the mechanical and rheological properties of polybutadiene succinate based nanocomposites with nanoclay

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Abstract:
Depleting natural resources urge development of novel materials with increased biobased content. Properties of presently available polymers do not confirm all requirements of manufacturing industries. Consequently, there is a necessity to develop biobased polymer composites with improved set of properties. Due to its layered structure, nanoclay is a promising naturally derived functional filler for increasing both solvent/gas barrier properties and mechanical behavior of polymer nanocomposites. To achieve the neccessary interfacial interaction between hydrophobous polymer matrix and hydrophilic nanoclay, two general approaches are used individually or in combination: organomodification of nanoclay and functionalization of polymer matrix.
In the current research the effect of nanoclay on the mechanical and rheological properties of polybutylene succinate (PBS) and its co-polymer with adipic acid (PBSA) is investigated. PBS and PBSA composites with organically modified nanoclay (ONC) were obtained by melt compounding at different concentrations (0-5 wt.%) of the nanofiller. Mechanical properties of the developed nanocomposites were determined by means of DMTA and quasistatic tensile stress-strain tests. Processability of the developed nanocomposites over the temperature range of 120ºC-160ºC was characterized by means of rotational viscometry. The change in mechanical and thermal properties of the developed nanocomposites was correlated with structure changes caused by modifying the polymer matrix with NC. Structure of the developed nanocomposites was characterized by SEM, XRD, DSC and FTIR.
It is demonstrated that by using the chosen technological parameters of melt compounding regular distribution of NC within the biobased polymer matrix has been achieved. Besides, addition of NC considerably influences crystallization process of PBS and PBSA by causing the development of a fraction with more perfectly aligned crystallites. As a result, tensile modulus and strength of the investigated composites are increased, whereas ultimate relative elongation is maintained above 200% (Figure 1).

Keywords: polymer, nanoclay, nanocomposite, melt compounding, mechanical properties, rheological properties.

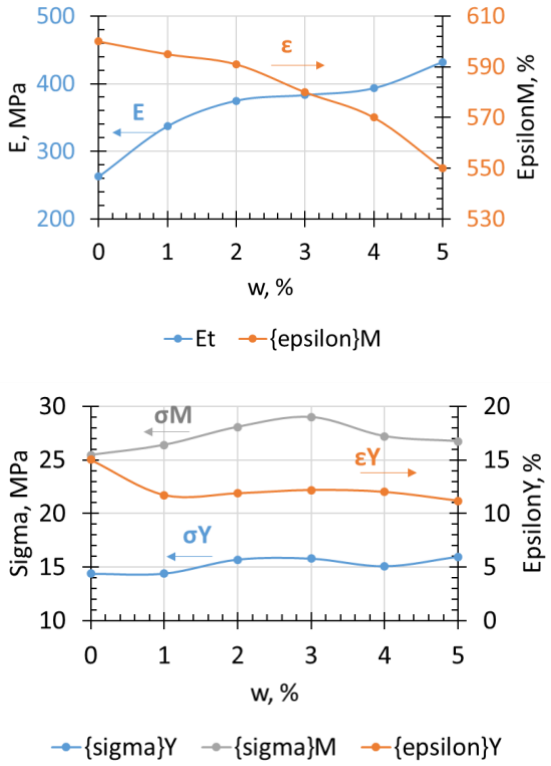

Figure 1: Figure illustrates that tensile modulus (E) and tensile strength at yield and strength at break (σM and σB, respectively) are increased by increasing the NC content in the PBSA matrix up to certain critical concentration, whereas relative elongation at yield point and elongation at break (εM and ε, respectively) decreases. However, ultimate relative elongation (ε) at miximum NC content is 550%.

Acknowledgement: This research is funded by the Latvian Council of Science, project "Smart Materials, Photonics, Technologies and Engineering Ecosystem" project No VPP-EM-FOTONIKA-2022/1-0001

Real-time observation of molecular stacking using Low-Energy Electron Microscopy

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Abstract:
The design of metal-organic interfaces with atomic precision and the ability to analyze molecular stacking order at the interface quickly and reliably is of crucial importance. The interfacial stacking order of molecules directly affects the quality and functionality of organic-based devices. Dark-field imaging using Low-Energy Electron Microscopy (LEEM) enables the visualization of areas with different structures and symmetries. However, imaging atomic layers with different stacking orders that exhibit the same diffraction patterns becomes more challenging.

In this presentation we will demonstrate the possibility of obtaining dark-field images with different contrast from self-assembled molecular bilayers when the second layer molecules are positioned asymmetrically with respect to the first layer, and bright-field analysis of second layer formation as shown in Figure 1. Particularly, we employ 4,4'-biphenyl-dicarboxylic acid (BDA) bilayers deposited on Ag(100) substrate, a system whose properties we have extensively studied for sub-monolayer to full monolayer coverage [1,2]. Scanning Tunneling Microscopy (STM) imaging of molecular bilayers allowed us to compare the measured shift directly. Additionally, we present a simplified diffraction model based on the electron path differences that agrees with the observed phenomenon. We will also introduce our new ProLEED studio software, which significantly helps with the analysis of diffraction images.

Keywords: self-assembly, molecular stacking, LEEM, DF imaging, ProLEED studio, diffraction.

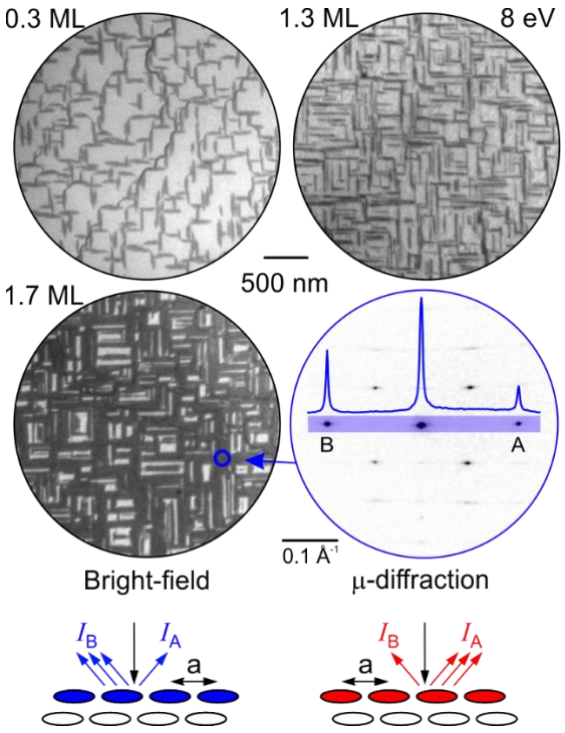

Figure 1: Bright-field images of 0.3ML, 1.3 ML, and 1.7 ML of BDA molecules on Ag(100) surface measured by LEEM at 8 eV. μ-diffraction image measured from a circular area with a diameter of 185 nm shows the distinct intensity of (1 1) and (-1 -1) spots. The molecular stacking model explains the origin of intensity differences.

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Investigation of atomically-thin 2D indium intercalated under epitaxial graphene on SiC using scanning tunneling microscopy

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Abstract:
Two-dimensional (2D) metals can be stabilized at the interface between epitaxial graphene (EG) and silicon carbide (SiC) interface and offer fascinating platforms for quantum and electronics applications [1,2]. In this work, our goal is to provide a microscopic insight into the structure of atomically-thin indium layers intercalated at EG/SiC interface by means of scanning tunneling microscopy. We observed distinct atomic structures of the intercalated indium mono- and bi-layers under graphene through strong interaction with graphene and SiC substrate. On the single indium layer, our STM images show atomic resolution of indium atom array which are in epitaxial registry with the underlying SiC substrate. This epitaxial match between the indium atoms and the SiC lattice creates a (2×2) superstructure with a periodicity of 0.49 nm (Figure 1). In addition, the misalignment of the indium monolayer with the coverlayer graphene induces a larger superstructure with lateral periodicity of 3.2 nm which corresponds to a (13×13) of graphene unit cell. These two distinctive superstructures coexist in the STM image taken at unoccupied energy, while graphene becomes transperant at this voltage. In a contrast, no particular lattice structure is observed on the bilayer indium region. The doping of graphene which were identified by local spectroscopy varies depending on the intercalation level. The graphene above the intercalated monolayer is strongly n-doped and drastically reduced above the bilayer region. Single occupied state is clearly observed on indium bilayer while is absent on the monolayer. We further demonstrated the metastable character of the confined indium atoms using tip-induced manipulation. Under certain imaging condition, indium atoms can laterally displace along the atom array via position exchange with the nearby vacancies in the layer. This displacement of the indium atoms shows their fragile nature in the monolayer under the electric field induced by the STM tip. The intercalated atoms can eventually be locally desorbed by applying a bias voltage pulse from +4V, exposing only monolayer EG stacking with the SiC without the intercalated atoms. In addition, the desorbed atoms tend to reconstruct their more stable structural configuration, namely bilayer indium, in the nearby region with the tip location under graphene.

Keywords: 2D metal, epitaxial graphene, SiC, intercalation, scanning tunneling microscopy.

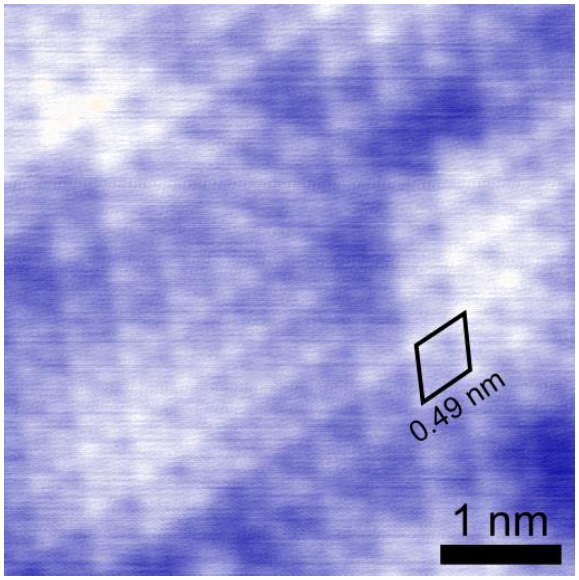

Figure 1: STM topography image of indium monolayer intercalated underneath EG on SiC substrate. Its atomic resolution is clearly seen as small spherical dots. The large and small superstructures of 3.2 nm and 0.49 nm are visible which are due to the interaction of indium array with graphene lattice and the underlying indium, respectively.

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Electrochemical Sensor for Benserazide: Molecularly Imprinted Polymer on a Paper-based Platform

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Abstract:
Affecting almost 3% of over 65 years old population, Parkinson's disease (PD) is the second most common neurodegenerative disease [1]. Benserazide is a peripheral dopadecarboxylase inhibitor and is administered in association with levodopa in the treatment of PD. The consumption of therapeutic drugs all over the world is a major environmental issue, since those compounds are not fully metabolized in the organism and are excreted by the organism, and together with low removal efficiency in wastewater treatment plants, they find the way into the biota. In the last years, the use of paper-based analytical devices (PAD) has exponentially increased, with the rising interest in cheap and easy to use point of care analytical devices. Molecularly imprinted polymers (MIP) are synthetic materials that mimic biological recognition elements, and can be use for environmental analysis together with electrochemical detection devices [2]. Although PAD's have been reported for several years [3], the association of molecularly imprinted polymers and electrochemical detection is in its early stages. In this work, a simple and low-cost electrochemical sensor for Benserazide is built in a paper-based platform, and molecular imprinted technology is performed to enhance selectivity to the sensor. The proposed sensor is easy to prepare. The analytical response of the proposed sensor was linear in the range of 5.00 µM to 1.00 mM with a LOD of 98.4 µM. Selectivity studies were performed with three other molecules, that exhibit similar structures to BNZ. After the construction of the sensor, sample analysis is performed in 20 min.

Keywords: electrochemical sensors, molecularly imprinted polymers, paper-based electrodes, benserazide, wastewater monitorization.

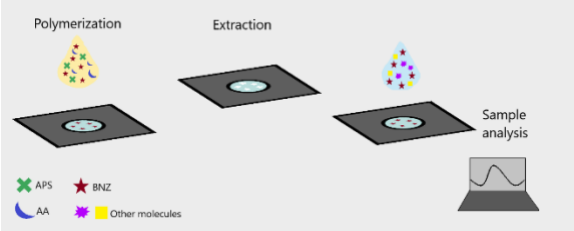

Figure 1: Schematic representation of the MIP sensor construction.

Aknowlwgments:

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Molecularly imprinted polymer-based electrochemical sensor for simple and fast analysis of tetrodotoxin

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Abstract:

Tetrodotoxin (TTX, Figure 1) is highly poisonous to humans and is found in some animal species (e.g., pufferfish). TTX acts by blocking sodium channels in nerve cells, preventing the transmission of nerve impulses, leading to muscular paralysis. Just a few micrograms can be lethal to humans, so its determination in foods is of utmost importance [1].

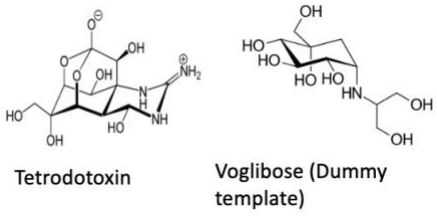
Some immunosensors for the analysis of TTX have been developed, but the difficulty and costs of obtaining specific antibodies for TTX and their instability on transducer surfaces demand the search for new analytical tools [2]. Due to their selectivity, chemical and physical stability, low cost, and easy preparation, molecularly imprinting polymer (MIP)-based electrochemical sensors have emerged as good alternatives. To the best of our knowledge, the development of MIP sensors for the determination of TTX has not been reported yet.

Accordingly, this work describes the development of a highly selective electrochemical MIP sensor for the determination of TTX. The MIP was produced using a cheap dummy template voglibose (VB), Figure 1, by electropolymerization. The detection was performed using voltammetric techniques with a redox probe ($[Fe(CN)_6]^{3-/4-}$) and screen-printed electrodes (SPE) (Figure 1).

Keywords: Tetrodotoxin; Neurotoxin; Molecularly imprinted polymer; Electrochemical sensor

Acknowledgments:

This work was financially supported by Portuguese national funds through projects UIDB/50006/2020 and UIDP/50006/2020 from the Fundação para a Ciência e a Tecnologia (FCT)/Ministério da Ciência, Tecnologia e Ensino Superior (MCTES). João Pacheco (SFRH/BPD/101419/2014) and Pedro Rocha (2020.06987.BD) are grateful to FCT and the EU for their grants, financed by POPH-QREN-Tipologia 4.1-Formação Avançada, funded by Fundo Social Europeu (FSE) and MCTES.



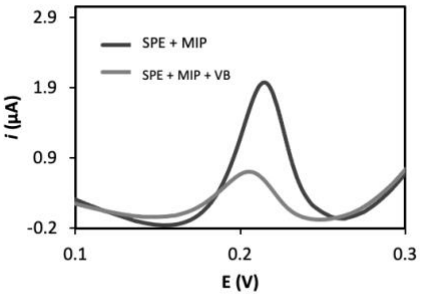


Figure 1: Chemical structures of TTX and voglibose. Comparison of sensor response before and after incubation with voglibose.

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An electronic nose based on CNTs functionalized with zinc phthalocyanine for wine aging detection

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Abstract:
Wine is characterized by numerous organoleptic and volatile components, which identify not only its chemical composition, or the type of grape used to produce that wine but can also be indicative for tracing its origin and controlling its quality [1]. Monitoring adulterations and composition of wine is quite important nowadays for industries mainly due to economic aspects [1]. Currently, the main techniques exploited to characterize wines by chemical composition and aroma are represented by high performance liquid chromatography and gas chromatography-mass spectrometry. The cost of such techniques, including instruments and skilled technicians, is high, and they are time-consuming. Therefore, the development and potential use of low-cost devices, whose data can be analyzed quickly, is of great interest for industries [2]. On the other hand, the analysis of the volatile organic compounds (VOCs) is an efficient method to obtain information about the chemical composition of fluids and it can be applied in several fields, including food and beverage quality control. Indeed, food and beverage emit particular gas molecules that can be an indication of both freshness and deterioration of a product [1-3]. If one can trace the presence of these gas molecules, it is possible to monitor the freshness/aging of a product.
The analysis of the VOCs through an electronic nose (e-nose), thanks to the high sensitivity of the sensors, their rapid response and ease of use, as well as their low cost and their capability to recognize numerous components exploiting multivariate analysis methods, is a technique which is gaining more and more attention in this area.
In this work an e-nose has been developed with the aim of tracking aging and adulteration of wine. The e-nose comprises 7 chemiresistor sensors based on carbon nanotubes functionalized with zinc phthalocyanine on a plastic substrate. Carbon nanotubes (CNTs) are known to be good candidates for gas sensing [4], while zinc phthalocyanine could increase the CNTs sensitivity towards selected VOCs, such as ethanol [3]. Principal component analysis (PCA) carried out on the data obtained from the e-nose show its capability to recognize the main volatile component of wine (ethanol and water) as well as two of the analytes considered biomarkers of wine aging: acetic acid and ammonia, opening the possibility to carry out tests on wine (Figure 1).

Keywords: electronic nose; carbon nanotubes; zinc phthalocyanine; wine aging; food and beverage application; PCA, gas sensors.

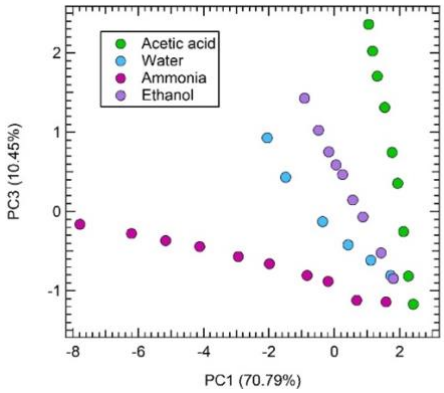

Figure 1: 2D PCA space. All tested gases are separated in the space, denoting the good discrimination capability of the developed e-nose.

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Impedimetric FIA enzyme inhibition-based biosensor system for determination of heavy metal ions in water

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Abstract:
Conventional heavy metal detection methods often require expensive equipment, highly skilled personnel, the application of complex operational procedures, long detection times, and they are not applicable for real-time detection [1,2]. Therefore, development of portable, highly sensitive, selective, and economical sensors is necessary for the detection of toxic metal ions in water [1]. This work was aimed to developing of new effective automatic flow injection analysis (FIA) biosensor system for heavy metal ions detection.
During the work a new FIA system integrated with an impedimetric enzyme inhibition-based biosensor for the determination of heavy metal ions has been designed and successfully tested. The automatic FIA system includes 6 computer-controlled pumps for selection and injection of 6 different fluids. The optimum flow rate of the system was 50 µl/min, where the biosensors showed high sensitivity and high signal reproducibility in continuous flow injection analysis. The optimal conditions of the process of inhibition and reactivation were found. The main analytical characteristics (sensitivity, reproducibility, storage stability, etc.) of four types of impedimetric biosensors based on urease, butyrylcholinesterase (BuChE), achetylcholine esterase (AChE) and glucose oxidase were studied. The sensitivity of enzyme inhibition-based biosensors toward 0.001-10 µM concentration of different heavy metal ions (Hg^{2+}, Ag^{+}, Cd^{2+}, Zn^{2+}, Ni^{2+}, Pb^{2+}, Co^{2+}, Cu^{2+}) was investigated. The procedure of heavy metal ions measurements is shown in Fig. 1. The possibility of reactivation of biosensors using EDTA was evaluated in order to reuse the biosensors for the inhibitory analysis of heavy metal ions in water. Continuous storage of biosensors for a 6 months in a dry state at a temperature of -4°C did not affect the biosensor's sensitivity, that indicates the possibility of their storage for at least a 6 months without loss of activity.
In future the developed biosensor system can be used for express evaluation of the presence of heavy metal ions in water.

Keywords: impediometric biosensor, heavy metal ions, enzymes, inhibitory analysis, flow injection analysis.

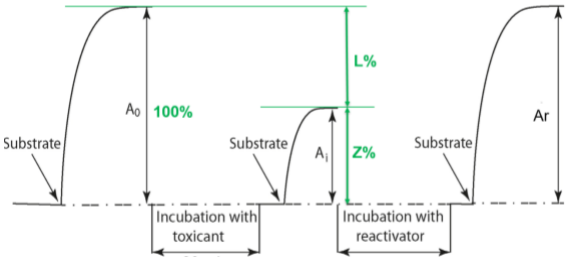

Figure 1: Scheme of inhibitory analysis.
Biosensor signals: A_0 — before inhibition, A_i — after inhibition, A_r — after reactivation.
Z - residual activity, L- level of inhibition.

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Acknowledgements:
This work is supported by CARA (the Council for At-Risk Academics) and National Academy of Science of Ukraine.
This study is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 958491, Project Waste2Fresh.

Development of biosensors for phenol compounds utilizing Langmuir and Langmuir-Blodgett nano-organized films containing laccase

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Abstract:
In this work, we evaluated the immobilization of laccase in nanostructured films assembled using the Langmuir-Blodgett (LB) methodology. For that, we employed three different chemical molecular matrices: octadecylamine, cholesterol, and the conductive polymer Poly (3-hexylthiophene-2, 5-diyl) (P3HT). We also added carbon nanotubes as an adjuvant to facilitate the energy transfer for optical and electrical detection. The Langmuir monolayers were formed at the air-water interface by spreading on it organic solutions of the amphiphiles, and the enzyme and carbon nanotube were incorporated from an aqueous solution/dispersion as a subphase. We observed that the supramolecular architecture provided by the hybrid monolayer conserved the enzyme's structure, and then the floating monolayers were transferred to solid supports (ITO - glass) by the LB methodology[1]. The ultrathin film was then employed as an electrode surface for cyclic voltammograms to obtain the total content of phenolic compounds in standardized solutions as well as based grape samples. To better understand the physical - chemical properties of these LB films, we first investigated the physico - chemical properties of the previous floating monolayers using tensiometry, Brewster angle microscopy (BAM), polarization modulation infrared reflection absorption spectroscopy (PM-IRRAS), surface potential, and rheological methods like floating needle (FN) and barrier oscilation (BO). The LB films were characterized by UV-vis and infrared spectroscopies, quartz crystal micro - balance, Atomic Force Microscopy (AFM), as well as voltammetric measurements to investigate in detail the viability of LB films produced for sensors of phenolic derivatives associating with estimations of enzymatic activity by colorimetric methods and voltammetry measurements. The results are evaluated against the preservation of catalytic activity, stability of formed films, limits of detection and quantification, in addition to their implications in nanobiotechnology. We intend to do the cyclic voltammetric and AFM approach at valladolid university (UVA). The PM-IRRAS approach will be done at University of São Paulo.
Keywords: Langmuir-Blodgett, Biosensors, Laccase, Phenol, Electronic tongue.

Figure 1: Image illustrating the structure of laccase.

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Flexible copper nanowire-based electrodes: Optical and mechanical properties for soft electronics

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Abstract:
Indium tin oxide (ITO) is one of the most widely used commercial transparent conductive electrode due to its favourable properties [1]. However, due to its high toxicity [2] and brittleness [3], it is not well suited for transparent flexible electrodes or soft electronic devices. In recent years some focus has shifted toward investigating the potential of developing transparent flexible solar cells. Compared to other rigid cells, flexible solar cells have several benefits such as improved portability, durability, flexibility and usage with curved surfaces [4]. Polymer substrates have been found to have both excellent optical transmittance as well as flexibility which makes them ideal for the potential usage as transparent flexible electrodes for soft electronic devices. Herein, we report on the hydrothermal synthesis of copper nanowires (CuNWs) as transparent films on flexible polymer substrates for application in soft electronics such as flexible solar cells. The CuNWs were deposited onto polymer substates such as polyethylene terephthalate (PET), polyethylene naphthalate (PEN), Polycarbonate (PC) and Polyethersulfone (PES). Thereafter, aluminium (Al) and gallium (Ga) doped zinc oxide (ZnO) nanoflakes, also known as AZO-NFs and GZO-NFs, were synthesized, and coated onto CuNWs to act as a protective layer against CuNWs' oxidation. SEM images showed multiple, long and smooth CuNWs with the average diameter of approximately 117.75 nm and an ultra-long length of over 50 µm. UV-VIS-NIR results showed that a bare PET substrate has a higher light transmittance of ~88.64%, followed by PES with ~85.78%. These were slightly higher than those of a bare PC (~87.93%) and PEN (~81.78%). AFM indicated CuNWs roughness values of ~46.35 nm for PEN, followed by PET, PES and PC values of ~73.24, 77.51 and 109.01 nm, respectively. The mechanical (stress-strain) properties of the prepared electrodes were also studied (Figure 1). The yield strength, ultimate strength, Young's modulus and resilience of the electrodes are amongst the parameters that were evaluated and discussed in detail.

Keywords: soft electronics, copper nanowires, flexibility, strain-stress, polyethylene terephthalate, polyethylene naphthalate, Polycarbonate, Polyethersulfone.

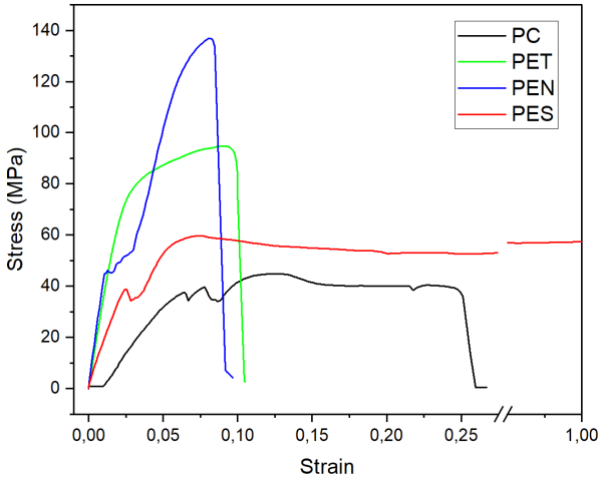

Figure 1: Stress – strain plot of the polymer substrates PC, PET, PEN and PES.

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Degradation Analysis of Organic Solar Cells.

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Abstract:

Currently, a significant amount of research is dedicated to enhancing the efficiency of photovoltaic devices. Different approaches are being explored to improve factors such as fabrication ease, carbon footprint, power conversion efficiency (PCE), and electrical characteristics. A promising area of development involves the use of organic nanocomposites and hybrid versions doped with nanoparticles, nanorods, and similar materials. Despite the fact that traditional silicon solar cells have dominated the market for decades due to their high PCE, there is certain uncertainty about their lifetime and susceptibility to external factors. In contrast, organic and hybrid solar cells offer the potential for more stable electrical characteristics and PCE over time. This study focuses on analyzing the degradation of solar cells with an organic structured based on a PEDOT:PSS transportation layer and a P3HT:PCBM active layer. The research considers variations in different fabrication stages, such as the solution ratios involved in the layer structure, solution volumes, inclusion of other dopants, and dispersion temperatures. The electric parameters and efficiency parameters were periodically measured for over 4 months. These measurements led to the development of regression and inference statistical models, forming the basis for analyzing the degradation and lifetime of these devices. The experimental results validated these models in terms of the sum of squared error, the root mean square error, and the coefficient of determination.

Keywords: organic optoelectronics, solar cell, degradation, lifetime, nanocomposites.

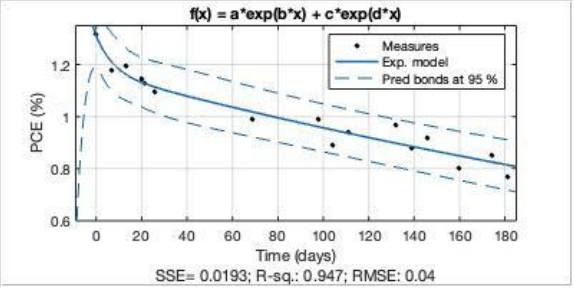

Figure 1: Non linear statistical regression for the PCE decadence through an exponential model.

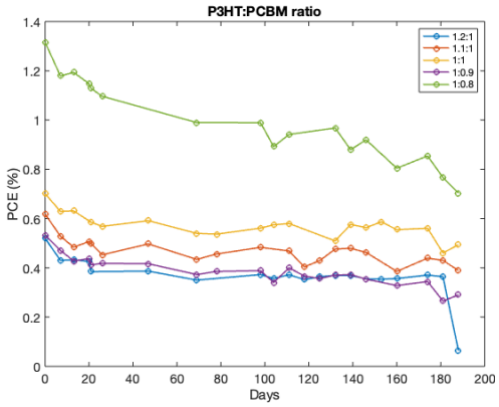

Figure 2: PCE decadence vs. time for different P3HT:PCBM ratios.

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Improvements on Carbon Based Porous Silicon Supercapacitor Through Electrochemical Deposition of Cobalt Hexacyanoferrate Nanocubes

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Abstract:

This work focuses on improving the charge storage performance of the previously assembled and tested p-doped porous Si electrodes coated with 7-hydroxy-1,2,3,4-tetrahydro-naphtalene-2-carboxylic acid through electrodeposition and thermally treated at 800° C for 4h in N_2 atmosphere[1](SiC). In order to improve upon the obtained results, the additional process consisted in the growth of CoHCF nanocubes on the porous Si's carbonic surface[2](SiC+CoHCF). The obtained electrodes were assembled in a parallel plate configuration together with PVA + H_2SO_4 and $LiClO_4$ respectively as the electrolytes between the two plates. In order to assess the performances, electrochemical impedance spectroscopy (EIS) was initially performed on the two capacitors. Fig. 1a&b show that at high frequencies, between 1 to 10 kHz, SiC+CoHCF presents a more pronounced capacitive behaviour, which could indicate an increase in the interface's width, since its increased visibility at high frequency would betray a smaller capacitance, hence an increase in the distance between Si and the double layer. While the lower frequencies, <1 Hz, the behaviour looks quite similar, there is an apparent pronounced charge transfer increase, hence the significant distancing from the ideal 90° phase for SiC+CoHCF. Cyclic voltammetry (Fig. 1c&d) curves (CV) show that while the charge storage for SiC has a pronounced pseudocapacitive element to it, the one for SiC+CoHCF seems to be predominantly at the surface. Ultimately, through charge-discharge curves (GCD) at 1mA (Fig. 1e.), the SiC+CoHCF shows a serious increase in the working potential, as well as one in discharge time, therefore a notable increase in performance.

Keywords: porous silicon, energy storage, supercapacitor, pseudocapacitance, electrochemical measurements

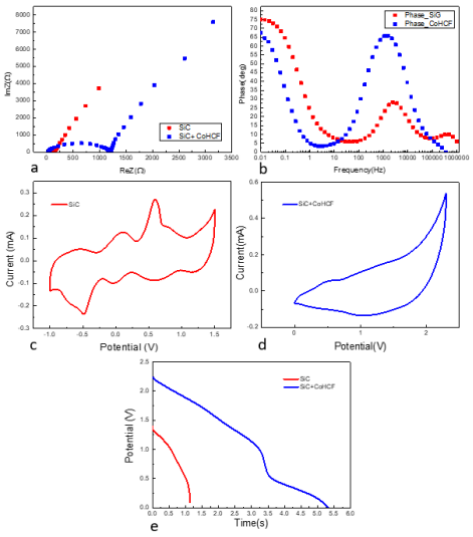

Figure 1: a. Nyquist for SiC vs Nyquist for SiC+CoHCF b. Bode for SiC vs Bode for SiC+CoHCF c. CV @ 50mV/s for SiC d. CV @ 50 mV/s for SiC+CoHCF e. GCD @ 1mA for SiC vs SiC+CoHCF

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Charge injection layers from carboxylic acid molecules

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Abstract:
Organic semiconductors (OS) are an attractive option for a wide range of electronic applications due to the combination of unique properties. However, OS-based devices are often limited by the contact resistance between the OS layer and a metal electrode that arises from the misalignment of their energy levels. Adding a monolayer thick charge injection layer (CIL) between the electrode and the OS layer can chemically decouple the OS from the electrode and align the molecular levels with the substrate. Building such a multilayer molecular system requires choosing the suitable molecule(s) and having the means to analyse and control it.
We take Ag(001) and Ag(111) as a substrate where the homo- and heteromolecular layers of 4,4'-biphenyl-dicarboxylic acid (BDA), and 1,3,5-Tris(4-carboxyphenyl)benzene (BTB), in combination with pentacene (5A) are built to be used as CILs. We analyse the systems by using several complementary techniques built within a unique UHV cluster. LEEM is used to characterise the mesoscopic properties of molecular layers, STM to identify the exact molecular ordering within the layers and XPS to get chemical information. Work function measurements are conducted by UPS. We show that carboxylic acids are perfect molecules for building stable CILs with tunable work function by the process of dehydrogenation.

Keywords: self-assembly, heteromolecular layers, BTB, BDA, pentacene, LEEM, STM, XPS, UPS, energy level alignment, charge transfer, work function

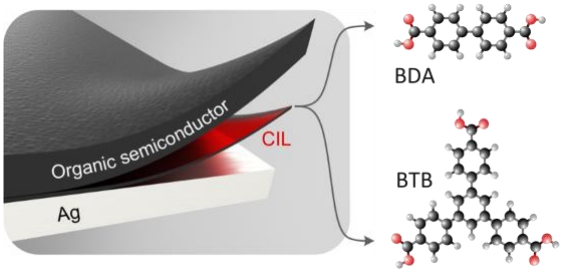

Figure 1: Schematic overview of OS device with implemented CIL based on carboxylic acid molecules (BTB or BDA).

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Conductimetric microsensors integrating phthalocyanine nanolayers : high-performance sensing devices for the measurement of NO_2 at ppb level in atmosphere

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Abstract:
Metallophthalocyanines constitute an extended class of molecular organic semiconductors that the extrinsic electronic conductivity can be strongly modulated by the adsorption of oxidizing species. More especially, taking into consideration the great number of pi-electron delocalized on each macrocyle, adsorbed oxidizing pollutants like NO_2 and O_3 induce high p-type conductivity variations whereas adsorbed reducing pollutants like CO, NH_3 or H_2S not lead to significant response in the same range of concentrations. If previous results report the high sensitivity of phthalocyanine-based microsensors to NO_2 associated to a limit of detection and resolution closed to few ppb, O_3 remains the major interfering pollutant leading to substantial cross-sensitivity and long-term degradation of sensing layer by ozonolysis process. Moreover, the effect of sensing layer thickness on metrological performances as well as effects of humidity on response have never been investigated in this range of concentrations.
This paper deals with the last sensing performances of conductimetric microsensors integrating nanolayer of phthalocyanines as sensing membrane operating at low working temperature. Investigations on layer thickness influence on sensor sensitivity established that 100nm is the optimized thickness and that thicker layers are not appropriate. With the benefit of a high signal/noise ratio, such microsensors are highly efficient to measure NO_2 in the 4-20 ppb range of concentration with a high level of repeatability and reproducibility, whatever the concentration variations in air, increasing or decreasing (figure 1). The limit of detection was assessed to 0,4 ppb while the selectivity is high, the response to the most interfering gas, i.e. ozone, remaining two times lower than this measured for the same concentration of NO_2 (figure 2). Study of the effect of humidity highlights that highest responses were obtained for moderate relative humidity. Below 40% of relative humidity and above to 70%, microsensor response remains of weak magnitude. Hysteresis, mid-term stability and reproducibility of microsensors will be at last discussed.

Keywords: Phthalocyanine; nanolayers; conductimetric sensor; microsensors; nitrogen dioxide; gas sensitivity; air quality monitoring; ppb range.

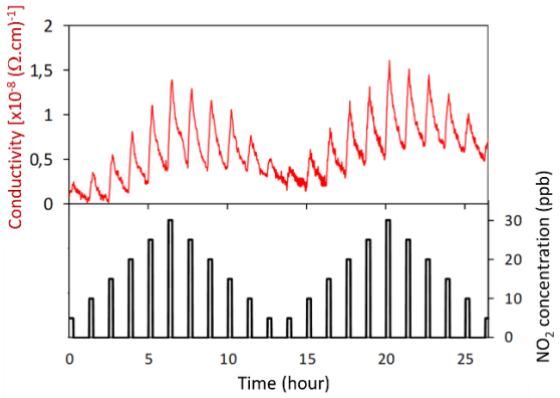

Figure 1: Dynamic response of phthalocyanine-based chemoresistor exposed to various concentrations of NO_2 in the 5-30 ppb range. Each exposure sequence consists in 15min of NO_2 exposure with consecutive 60min of recovery under clean air. Sensing layer thickness is 50nm, relative humidity is closed to 0.3% and the operating temperature is set to 60°C.

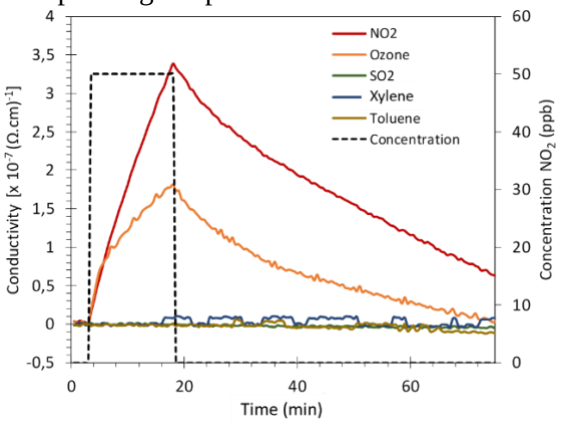

Figure 2: Conductivity variations versus time of conductimetric transducer coating by 50nm of CuPc during exposure to various pollutants. For each exposure, microsensor is maintained at 60°C, exposed to pollutants during 15min and then recovered under clean air during 60min. The concentration of all pollutants is 50ppb.

(Bio)Chemical Stretchable Sensors in Wearable Health Monitors

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Abstract:
The increasing prevalence of chronic diseases has fueled a demand for non-invasive wearable technology, with a particular emphasis on material innovations that enable daily monitoring of biological compounds. This study delves into the pivotal role of advanced materials in the development of (bio)chemical sensors within wearable devices, highlighting their indispensability in assessing health conditions through electrochemical methods [1].
Printed electronics (PE) technology's remarkable adaptability in creating flexible devices on various stretchable substrates using innovative printable materials has ushered in a revolution in the realm of wearable devices [2]. This adaptability extends the potential applications of wearables from health monitoring to human-machine interactions, offering far-reaching possibilities [3]. Notably, PE allows for fabrication on stretchable and conformable substrates such as thermoplastic polyurethanes (TPU), facilitating seamless integration into textiles and promoting interaction with the human skin [4].
In this research, we harness the capabilities of stretchable electronics and innovative materials to introduce a fully integrated non-invasive wearable device designed for the continuous monitoring of glucose and lactate concentrations in sweat.
Critical components of this device encompass the utilization of stretchable substrates like TPU and the incorporation of materials such as graphite, silver/silver chloride and Prussian blue, where enzymatic membranes have been thoughtfully deposited.
After the fabrication, the printed electrodes were characterized and validated with artificial sweat solutions, containing glucose and lactate ranging from 0 mM to 20 mM, demonstrating their reliability and accuracy with a proper enzymatic response. This research underscores the transformative potential of stretchable electronics and innovative materials, offering a flexible biosensor platform that transcends traditional medical applications.

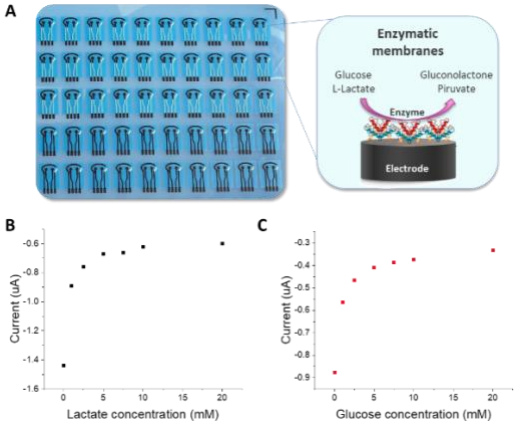

Figure 1: A) Image example of a sheet of the stretchable printed sensors and detail of the amperometry technique used to measure the concentrations of glucose and lactate. **B)** Amperometric lactate correlation and **C)** amperometric glucose correlation from 0 – 20 mM.

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Preparation of Water-Soluble Microspicule Composition using Hyaluronic acid

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Abstract:
As interest in skin health increases with the diversification of consumer trends and the aging population, the demand for Cosmetics Medical products for skin care is increasing. However, since the stratum corneum with a thickness of 10 to 60 ㎛ at the outermost part of the skin prevents external substances from penetrating the body, there is a limit to the absorption rate of active ingredients in the body.
Therefore, a transdermal delivery system is needed to increase the absorption rate of active ingredients. However, liposomes have different absorption rates depending on the substances that make up the liposome, and when the active ingredient is protein, stability maintenance problems occur, and injections or fine needles have good absorption rates, but they also cause considerable pain and infection.
In this study, water-soluble microspic particles were formed in an intaglio mold (Figure 1) using hyaluronic acid as a transdermal delivery system. Unlike conventional microneedle methods with pain, water-soluble microspic particle technology has the advantage of increasing skin delivery of active ingredients such as growth factor peptides and keeping unstable proteins stable for a long time without using mezzo rollers or stamps. However, the previously developed water-soluble microspic particles are water-soluble microspic particles in the form of triangular or polygonal horns with a small tip, and there was a problem that a number of bubbles were formed inside during the manufacturing process of filling and drying in an intaglio mold. In this study, a manufacturing method of water-soluble microspicul particles that do not form bubbles inside and are easily separated from the mold was developed as well (Figure 2).

Keywords: Water-soluble microparticles, Hyaluronic acid, Intaglio mold, Cosmetics Medical, Skin delivery of active ingredients

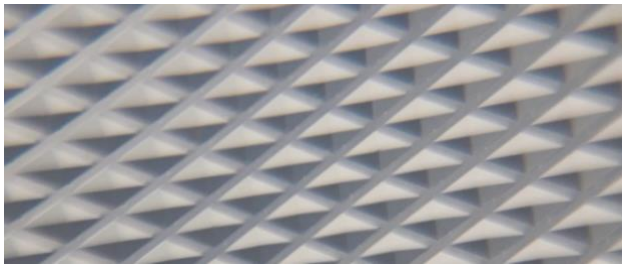

Figure 1: An intaglio plastic mold with a diamond pattern.

Figure 2: Water-soluble microparticles in the form of diamonds.

References:

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Antibacterial properties of Polytetrafluorethylene Nanotextile with Ag Nanoparticles Induced By High-Energy Excimer Laser

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Abstract:
In presented study, we focused on modification of porous PTFE nanotextile by sputtering of thin silver nanolayers and subsequent induction of silver nanoparticle formation by single-shot pulse of KrF excimer laser. The changes in surface morphology were studied and while the pristine PTFE substrate exhibited only minor changes due to excimer laser exposure, significant changes have been observed on the silver sputtered PTFE surfaces. Applying excimer laser led to formation of silver nanoparticles [1] and wettability very close to that of a superhydrophobic surface was measured on created PTFE-Ag composite. Formation of superposed globular structures on the PTFE lamellar primary structure was confirmed by both scanning electron microscopy (SEM) and atomic force microscopy (AFM) as can be seen in **Figure 1**. Combination of changes in surface morphology, chemistry and wettability induced significant change in PTFE antibacterial properties. PTFE nanotextile samples coated with silver and further treated with excimer laser 150 mJ/cm^2 inhibited 100 % of Gram-negative *E. coli* bacterial strain. The motivation behind this study was to fabricate flexible and elastic material with hydrophobic character and antibacterial properties, that can be used in different types of applications, mainly in tissue engineering and the medicinal industry. The successful silver enhancement of PTFE surfaces thus shows promise in use for instance as antibacterial implant coatings or as supportive scaffolds for growth of bone cells and tissues [2].

Keywords: nanostructure, polymer, PTFE, silver nanolayer, laser exposure, antibacterial properties, morphology, wettability

Funding: This research was supported by Ministry of Health of the Czech Republic under grant No. NU20-08-00208.

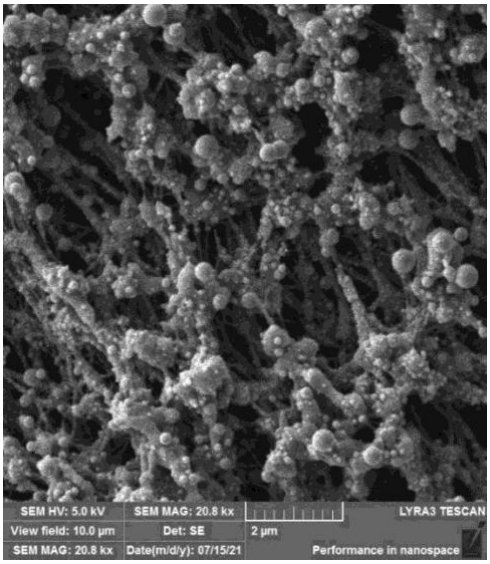

Figure 1: Detailed SEM image of PTFE nanotextile with sputtered Ag 300 s and subsequently treated with 150 mJ.cm^{-2}

References:

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Antibacterial and Photothermal Properties of Silver Nanoparticles: Paving the Way for Targeted Therapeutic Strategies

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Abstract:
The escalating global prevalence of bacterial infections caused by antibiotic-resistant bacteria poses a significant therapeutic dilemma. If the trend of increasing bacterial resistance continues unabated, these hard-to-treat infections may emerge as one of the leading causes of mortality worldwide. Consequently, the urgent need for novel antimicrobial agents or therapeutic strategies that target bacteria through alternative mechanisms, has become paramount. Silver nanoparticles (AgNPs) have emerged as a potential alternative antimicrobial, effectively eradicating bacteria at low concentrations without harming mammalian cells. AgNPs can be used alone, or in combination with antibiotics which no longer works against resistant strains, while the concentration of both antimicrobials is substantionally reduced and becomes effective again.[1,2] Embracing the multifaceted properties of silver nanoparticles may pave the way for personalized and targeted therapeutic interventions to combat bacterial infections and enhance disease treatment outcomes.
Additionally, silver nanoparticles hold promise beyond their antibacterial properties. Through precise control of their size, shape, and localized surface plasmon resonance, these nanomaterials exhibit tunable photothermal properties, where the energy of light is converted to heat, causing hyperthermia and damage to the cells. Such applications extend the potential use of silver nanoparticles in antibacterial and anticancer therapies, as well as the treatment of various diseases and studies of the disease pathology.

Keywords: bacterial resistance, silver nanoparticles, antibacterial therapy, synergistic effect, photothermal therapy, biomedical applications.

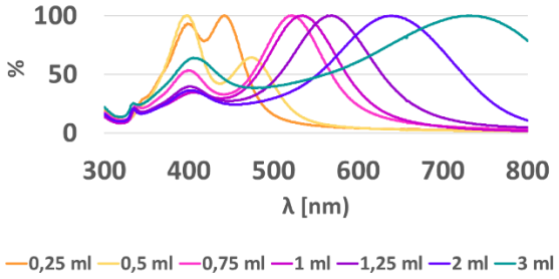

Figure 1: Absorption spectra of silver nanoparticles of different sizes, shapes, therefore plasmonic properties.

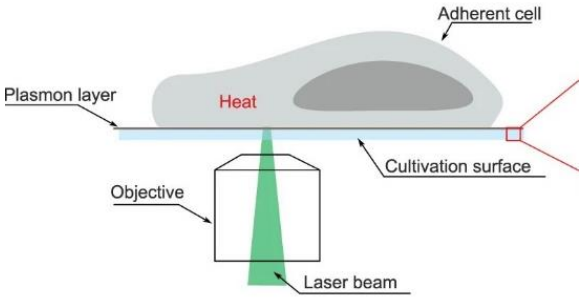

Figure 2: Cultivation surface of the wells modified via silver nanoparticles activated by a laser of appropriate wavelengths, which induces microthermal damage to cells/cellular proteins.[3]

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In vitro characterization of electroactive scaffolds for tissue engineering

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Abstract:
Nanofibrous materials are important in tissue engineering, primarily due to their ability to mimic the extracellular matrix which is naturally found in the human body. An ideal material for tissue engineering should be biodegradable and biocompatible to promote cell adhesion, proliferation and differentiation. When optimal properties are achieved, such a material can be used as a scaffold for cells for their subsequent implantation into damaged tissue. Electrical stimulation of cells on scaffold is also a current trend. This method has already been applied to various cell lines to promote cell proliferation, differentiation and orientation.

Our team is involved in the development, physical-chemical characterization and in vitro testing of nanofibrous materials with specific surface modifications - biocompatible polycaprolactone polymer with incorporated graphene nanoparticles. Nanofibrous materials are prepared by alternating current electrospinning (AC electrospinning) method. Thanks to the graphene, the scaffold becomes electroactive, which can have a significant effect on the regeneration of bone and nerve tissue. We determine material conductivity, wettability, degradation rate and the proportion of the graphene in material, which can also affect the biocompatibility of the material. *In vitro* characterization is performed using the osteoblasts and fibroblasts. Cells are cultured on the material for different time intervals and then fluorescently labeled to detect the number of nuclei, cell morphology and the ability to form focal adhesions on the substrate.

The aim of our contribution is to present current results in the design and subsequent biocompatibility testing of polymeric nanofibrous material (PCL) modified with graphene and various surface treatments. The material should be used as an electrically conductive scaffold in tissue engineering and regenerative medicine.

Keywords: Graphene, Polymers, Polycaprolactone, Scaffold, Biocompatibility, Tissue engineering, Regenerative medicine

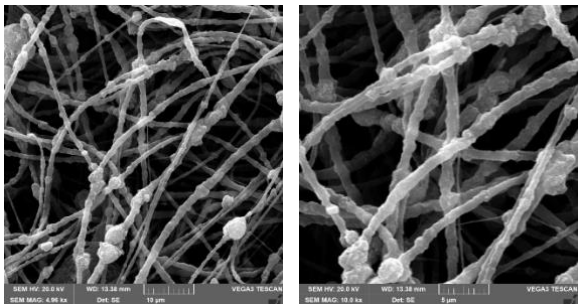

Figure 1: Scanning electron microscope images of polycaprolactone polymer with incorporated graphene nanoparticles. Magnification 5000x and 10000x.

References:

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Tribo-corrosion Evaluation of Electron Beam Melting Ti6Al4V-ELI for Biomedical Applications

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[2] UFABC, Universidade Federal do ABC, Santo André, Brazil
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Abstract:
Biomaterials surfaces need to be adequate to the function they perform; for this reason, the importance of studying surface finish increases as design requirements grow, regarding geometry and precision requirements in bioengineered materials. These biomaterials are subject to several types of premature failure, such as wear, fatigue, micro movements, particle detachment and degradation, which may generate the need for new interventions [1]. Titanium alloys have been widely used in the production of biomaterials due to their high physicochemical stability, mechanical resistance and biocompatibility. Currently, a route widely used on the implants production is the additive manufacturing using Selective Laser Melting (FSL) technology and Electron Beam Melting (EBM). The surfaces built by these technologies are covered with a certain amount of adhered material, which is partially melted on its surface, being a disadvantage in melting techniques using a bed of particulate materials, where a very smooth and low roughness surface cannot be achieved [2].
Additionally, surface characteristics are still influenced by the process parameters used in consolidation, in particular: power, speed, movement directions of the laser beam and other parameters.
The objective of this work was to evaluate the tribological and corrosion behavior of electron beam melting Ti6Al4V samples.
Titanium alloy samples was produced with Ti6Al4V-ELI (extra low interstitials) powder by electron beam melting technique, at 5 differrent speed parameters. Confocal microscopy was also used to evaluate samples roughness and topography. The tribo-corrosion tests were carried out during 10 min, solid spheres of 52-100 chrome steel, with 10 mm in diameter, were used as counter-bodies. The electrolyte used to simulate body fluids was Ringer´s solution at 37ºC. Current density and open circuit potential *versus* time were monitored throughout the test.
There is a tendency towards an increase in friction force values according to the surface topography.
The results indicated that the tribo-corrosion behavior is influenced by the Ti6Al4V-ELI surfaces finishing, and the wear rate is dependent of the normal force and the roughness of each sample; which is closely linked to the change in the speed parameters used in the preparation of the samples. Therefore, it is necessary to constantly advance research on the use of electron beam melting for biomaterials surfaces produced with titanium powder alloys.

Keywords: Titanium alloys, tribo-corrosion, electron beam melting, biomedical devices.

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Nano-texturing and high antibody adsorption of silicon nanoparticle surfaces for clinical application to enzyme-antibody methods

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Abstract:
ELISA (Enzyme-Linked Immuno Sorbent Assay) is widely used for quantitative measurement of antigens and antibodies. This technique uses microwell plates, which have limitations in the amount of protein adsorption and surface area. Due to these limitations, it is not possible to react the antigen and antibody to a wide range of concentrations, and the antigen and antibody amounts must be diluted to the appropriate concentration while checking the calibration curve in advance. We have developed mesoporous materials whose surface area can be freely extended and controlled to improve the detection range of antigen-antibody reactions. In our approach, we used silicon, which is inexpensive and easily surface-processable, and pore and convex shapes are formed on the particle surface by metal-assisted chemical etching. The silicon nanoparticles with such various shapes were modified with amino groups using NH-terminated coupling agents, and subsequently adsorbed with antibodies. In this presentation, we will introduce a novel diagnostic mesoporouos materials as an alternative to microwell plates used in enzyme-antibody assays and report on its surface morphology that can adsorb antibodies at high densitites. The silicon nanoparticles with pore or convex shapes can increase the amount of amino group modification due to their extended surface area, achieving the improvement of the adsorption of antibodies. Such developed mesoporous materials can detect antigen-anitibody reactions in vitro with high sensitivity due to its high-density antibody adsorption. Our research can detect a wide variety of cancer cells and/or viruses with high sensitivity, opening new doors in the field of diagnostics.

Keywords: surface processing, nanomaterials, silicon nanoparticles, enzyme-antibody method, amino-group binding, antibody adsorption

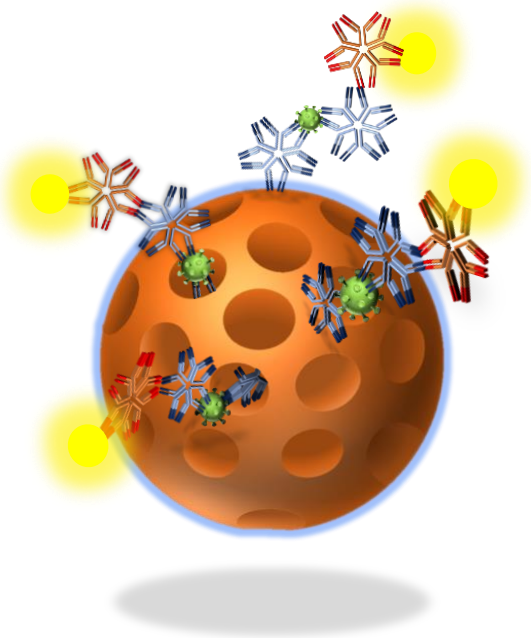

Figure 1: Schematic of enzyme-antibody method using sandwich techniques and adsorption of IgM antibody on silicon nanoparticles with pore shapes.

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Nanostructured system based on hydroxyapatite and curcumin: a promising candidate for osteosarcoma therapy

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Abstract:
Osteosarcoma is the most common type of bone cancer. Its treatment is based on systemic chemotherapy, that results in many side effects, and surgical resection with long periods of recovery. The 5-year survival rate remains in the range of 70% and in metastatic cases or with low response to chemotherapy, the rate is only 30% [1]. The use of nanotechnology for the development of more effective therapies is a promising tool for combating this type of cancer. Hydroxyapatite nanomaterials have unique properties that allow spontaneous accumulation in the tumor region, making them good agents to act as carrier for targeted delivery of drugs [2]. Curcumin has been researched over the years due to its medicinal properties including its anticancer property with low toxicity to healthy cells [3]. In view of the foregoing, the objective of this work is the synthesis and characterization of hydroxyapatite nanorods (nb-HA) to produce nanostructures functionalized with folic acid (AF), for the targeted delivery of curcumin (CM). The nb-HA were synthesized using the surfactant-assisted hydrothermal method. The nanostructures were obtained from the interaction of AF and CM with nb-HA, through the amination reaction. The nanostructures synthesized were characterized by X-ray diffraction analysis, scanning electron microscopy, Fourier transform infrared spectrometry, thermogravimetric analysis, elemental analysis CHN and X-ray photoelectron spectroscopy. The results indicated the obtaining of carbonated nb-HA and nanostructures constituted by nb-HA, AF and CCM with promisor features that credits this system for future biological assays in order to evaluate the efficiency of the nanostructures for the treatment of osteosarcoma.

Keywords: nanostructures, curcumin, hydroxyapatite nanorods, osteosarcoma, biomedical applications.

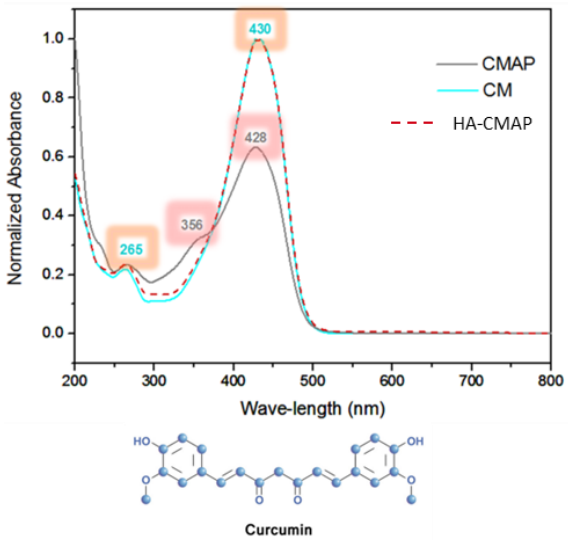

Figure 1: UV-Vis spectra of CM, CMAP and CMAP-HA samples. CM absorbs in the visible region with a maximum ranging from 410 to 430 nm, due to the excitation of the π→π* transition electron. The CMAP sample showed a maximum absorption band at around 430 nm, and the HA-CMAP-F spectrum, in addition to the absorption band at 435nm, it is possible to observe the presence of absorption bands at 356nm associated with the presence of folic acid, indicating the effectiveness of the functionalization.

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Extracellular vesicles as nanocarriers' biocoating for enhanced drug delivery in stroke

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Abstract:

With 101.5 million cases per year worldwide, stroke is classified as the leading cause of adult disability and second leading cause of mortality. In ischemic stroke, which covers 85% of all stroke cases, available treatments are only eligible in 7-13% of patients, with the majority having residual neurological impairments. Recently, it was shown that phosphodiesterase (PDE)4 inhibitors, such as Roflumilast, could reduce neuroinflammation and tissue damage. Application of Roflumilast in diseases of the central nervous system is not possible because of the emetic side effects associated with the required effective concentration. Therefore, a delivery system to specifically transport this drug to the brain would be highly desirable. In this regard, nanocarriers (NCs) composed of (bio)polymers or lipids have gained attention because of their drug stabilization properties and improved drug pharmacokinetics. However, their non-specific biodistribution remains a major concern. To overcome this hurdle, bio-inspired nano-coatings comprising extracellular vesicles (EVs) have carved a niche for themselves. In recent years, EVs have been widely reported to outperform lipid NCs with regard to luminal cargo delivery efficiency, due to their biomimetic properties that confer enhanced biocompatibility, cellular uptake and passage through the blood-brain barrier. In this project, we studied the impact of different coating methods (sonication, extrusion) and processing parameters (temperature, concentration, contact time) on EV-coating efficiency of polymeric NCs, generating so-called 'nanohybrids'. EVs were isolated from human KG-1 cells cultured in a high-density, continuous perfusion hollow fiber bioreactor using size-exclusion chromatography, and polymeric NCs, composed of 1,4-butanediol, phloroglucinol and toluene-2,4-diisocyanate, synthesized by inverse miniemulsion. To achieve an innovative drug delivery strategy for ischemic stroke, development of nanohybrids, and tools for monitoring their quality and stability is highly desired and timely.

Keywords: biomaterials engineering, extracellular vesicles, nanohybrids, ischemic stroke

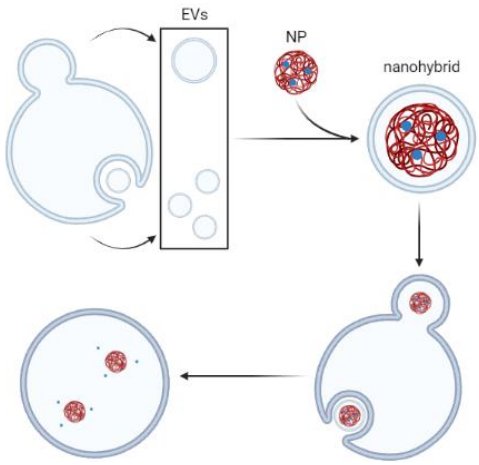

Figure 1: Figure illustrating the general project outline: coating NCs with EVs to form nanohybrids, for enhanced biodistribution and eventual drug delivery in stroke.

References:

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Star polymers as miR146a delivery system to regulate cardiomyocyte apoptosis after myocardial infarction

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Abstract:
Myocardial infarction is a leading cause of death worldwide, and as the currently used treatment protocols led only to the transient improvement of the heart function, there is a still need for a novel therapy which enable the full regeneration of heart tissues. One of such idea is to use the microRNA as a cardiomiocytes proliferation and apoptosis regulators. In order to effective introduce nucleic acids into cells, specific delivery system is needed. In our studies we used star polymers with cationic degradable core interacting with negatively charged miR146a through electrostatic interactions. The star polymer with a well-defined core size (between 10 and 50 nm in diameter) was prepared by the ATRP method. Next it was functionalized with microRNA by incubation for 3h at RT. The efficiency of miR binding was assessed by gel electrophoresis. The uptake of nanoparticles and intracellular delivery of fluorescently labeled miR were assessed by confocal microscopy. Cytotoxicity and genotoxicity of star polymers (non-functionalized and functionalized with miR) toward cardiomyocytes were tested by WST-1 and comet assay, respectively, and results indicated that our miR delivery system was not toxic to human cardiomyocytes. Flow cytometric analysis and staining of live cells with Mitosox revealed that cells incubated with star polymer did not enhance reactive oxygen species production. Our next step will be a functional assessment of its impact on hypoxia-induced cardiomyocytes.

Keywords: star polymers vectors, miRNA carriers, postinfarction treatment, cyto- and genotoxicity, intracellular localization, apoptosis regulation.

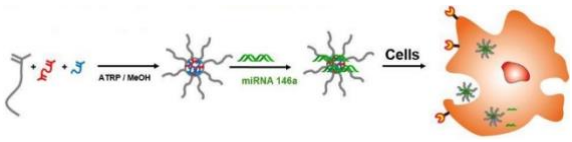

Figure 1 Schematic presentation of miRNA@star polymer assemblies' delivery.

Acknowledgements:
The research is financially supported by the National Centre for Research and Development DWM/WPC2/285/2020.

Lipid liquid crystalline nanoparticles as nanocarriers of miR let7g supporting cardiomyocyte maturation.

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Abstract:
Myocardial infarction and its following complications are one of the leading causes of mortality and morbidity worldwide. Despite intensive attempts to develop stem cell-based therapy using cardiomyocytes (iCM) obtained from pluripotent induced stem cells, full regeneration of heart tissues has not yet been achieved [1]. One of the possible reasons is seen in the fetal phenotype of the obtained cells. Therefore, in order to improve the maturation of iCM cells, we would like to propose lipid liquid crystalline nanoparticles (LLCNPs) as carriers for miR let7g.
We synthesized LLCNPs (with glycerol monooleate as structure-forming lipids, modified with DODMA cationic lipids) using a top-down approach. Next, we evaluated the physicochemical properties of lipid nanoparticles (particle size, colloidal stability, and morphology). Then, LLCNPs were complexed with miR by incubation for 1.5h at RT. Their uptake, cyto- and genotoxicity on human cardiomyocytes, as well as effects on reactive oxygen species production and mitochondrial membrane potential, were investigated. The changes in expression of genes related to metabolic switch and markers characteristic for mature cardiomyocytes were assessed by real-time PCR.
Our preliminary results indicated that LLCNPs modified with DODMA have the potential to positively impact cardiomyocyte maturation.

Keywords: lipid liquid crystalline nanoparticles, myocardial infarction, miR delivery, cardiomyocytes maturation

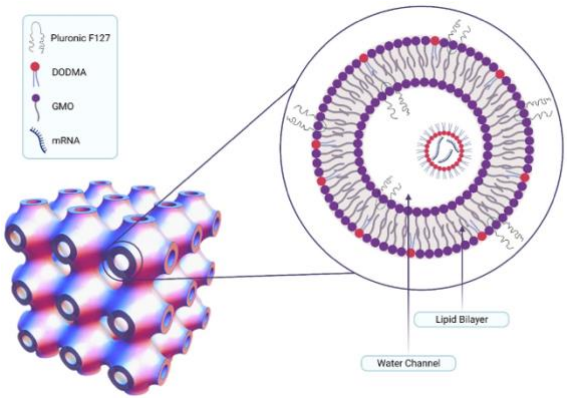

Figure 1: Predicted structure of glycerol monooleate-based lipid nanoparticle modifying DODMA cationic lipid, forming a highly ordered structure, cubosome.

Acknowledgments:
The research is financially supported by the National Science Centre Poland Miniatura 5 2021/05/X/NZ3/01013 and National Centre for Research and Development DWM/WPC2/285/2020.

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Nanoembedded Microparticles as an Innovative Drug Delivery System of a Therapeutic Peptide for the Treatment of Heart Failure

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Abstract:

The lack of effective therapeutic strategies for heart failure (HF) still determines worrying mortality and hospitalization rates. Recent developments have demonstrated that small biomolecules, such as peptides and non-coding RNAs, can have promising therapeutic activity by directly modifying the etiological molecular processes of the pathology and are more efficient than many traditional drugs. Given the promising therapeutic efficacy of these innovative molecules, there is a clear need to develop systems that allow their transport to the site of interest and increase their stability and cellular uptake capacity in order to make their beneficial activity possible and efficient. Here, an innovative drug delivery system mediated by bioinspired calcium phosphate nanoparticles (CaPs) incorporated into microparticles (dpCaPs) was developed to efficiently and safely deliver to the heart a therapeutic peptide (MP) that is able to modulate the trafficking of the L-type calcium channel (LTCC) impaired in HF. *In vitro*, *ex vivo* and *in vivo* studies were performed. In particular, as an *in vivo* pathological model, HF with reduced ejection fraction was induced in Göttingen minipigs using inhalation as the route of administration. It was shown that the nano-micro formulation can modify the molecular processes involved in HF at the cellular level and has a strong ability to restore cardiac activity and reduce pulmonary congestion in the pathological model. Finding an effective system to deliver a promising therapeutic peptide to the diseased heart could pave the way for a revolutionary treatment for HF patients

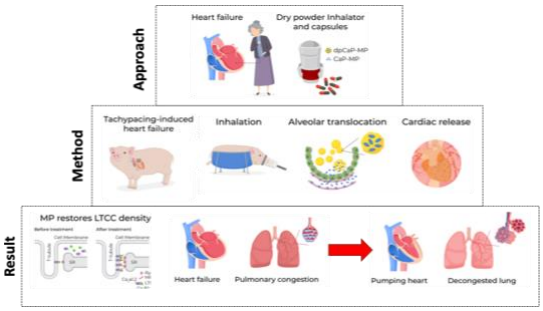

Figure 1: Schematic representation of the project.

Keywords: nanoparticles, mircoparticles, peptide, drug delivery, inhalation therapy, cardiac diseases, heart failure, calcium channels.

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$NaYF_4:Yb^{3+}/Er^{3+}$ upconverting nanoparticles for imaging and therapy

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Abstract:
Hexagonal upconverting nanoparticles (UCNPs) NaYF4 are interesting for their potential in biomedical imaging due to their unique optical properties, which enable their excitation by near-infrared (NIR) light and emission in visible (VIS) or ultraviolet part of the spectrum [1]. Therefore, they can be excited deep in the tissue and emitted light might trigger photodynamic therapeutic processes. To avoid problems caused by their poor stability and biocompatibility, recent studies have focused on surface modification of UCNPs using various polymers such as poly (N,N-dimethylacrylamide) (PDMA) and polyethylene glycol (PEG). In this study, we tested safety and optical properties of UCNPs with several coatings.

Bare NaYF4:Yb3+/Er3+ particles were prepared were prepared by high-temperature coprecipitation of lanthanide chlorides in high-boiling organic solvents. [2], their surface modified with alendronate and Poly(N,N-dimethylacrylamide) (PDMA) or poly (methyl vinyl ether-co-maleic acid) (PMVEMA). NaYF4 core size was 125 nm. Particles were tested in vitro to ensure their biocompatibility. UCNPs revealed no hemolytic activity regardless their coating and cytotoxicity tests revealed that cell viability over 80 % for UCNP concentrations up to 25 µg/mL.

A pilot experiment aimed on verification of UCNP fluorescence in vivo was performed. UCNPs were applied to mice with an implanted tumor subcutaneously or intratumorally. The fluorescence signal of UCNPs at 530 nm can be easily detected after excitation at 980 nm. Signal intensity subcutaneously applied UCNPs was significantly higher that the signal of intratumorally applied particles due to higher absorption of VIS light in the dense tumor tissue (Figure 1).

To conclude, upconverting particles coated by PEG or PDMA revealed no hemolytic activity. Concentrations up to 25 µg/mL can be considered as non-toxic and may be used for in vivo imaging or therapy without additional harmful side effects. Pilot in vivo experiment confirmed that the particles can be exited deeper in the tissue, as NIR light penetrates the tissue more easily than VIS. UCNPs therefore may serve (in combination with a suitable photosensitizer) as an agent for photodynamic therapy (PDT) in the future.

Keywords: uponverting nanoparticles, fluorescence imaging, photodynamic therapy, tumor

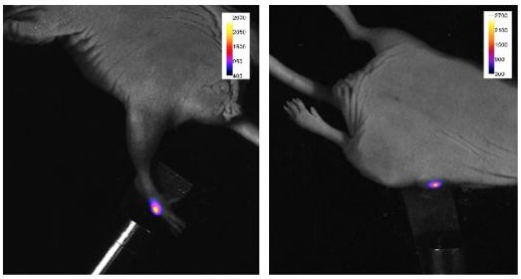

Figure 1: UCNP fluorescence after subcutaneous (left) and intratumoral (right) injection.

Acknowledgement:
This work was funded by grant GAČR (21-04420S) and Imaging infrastructure of CAPI, which is funded by MEYS of the Czech Republic (Czech-BioImaging LM2023050).

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Antitumor activity of HPMA copolymer conjugates bearing docetaxel and platinum-based drug for the treatment of head and neck cancer

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Abstract:
Head and neck cancers account for 4 % of all malignancies worldwide. Their incidence is increasing, yet the development of chemotherapeutics in this area is stagnating for decades. One promising option appears to be the use of HPMA copolymeric conjugates bearing the conventional drugs. The drugs are bound to the polymeric carrier *via* pH-sensitive bond and this binding provides an improvement in the pharmacokinetics of the drug, prolongs its circulation time in the bloodstream, avoids side effects and also allows passive accumulation of the drug in the tumor tissue due to the EPR effect. We studied the anticancer activity of polymeric conjugate bearing picoplatin derivative with 2-oxobutylpyridine linker and docetaxel derivatives with 5-methyl-4-oxohexanoic and levulinic acid both *in vitro* and *in vivo*. We report the data showing high anticancer activity of these compounds *in vitro* in FaDu, SCC7, 4T1 and LL2 cell lines observed using ^{3}H-thymidine incorporation assay (cytostatic activity), MTT assay (cytotoxic activity) and Annexin V assay (apoptosis induction). After these initial tests we studied their toxicity and anticancer activity *in vivo* in BALB/c mice bearing CT26 or 4T1 tumors and RAG2$^{-/-}$ mice bearing FaDu tumors. Polymeric conjugate bearing docetaxel derivative with levulinic acid showed strong effect on inhibition of CT26 tumors and its application in RAG2$^{-/-}$ mice with FaDu tumors led to complete regression of all the tumors within the experimental group. Thus, this conjugate represents a potentially promising tool for the treatment of head and neck cancers as well as other tumors.

Keywords: HPMA copolymers, head and neck cancer, platinate, docetaxel, cytostatic and cytotoxic activity *in vitro*, anticancer activity *in vivo*.

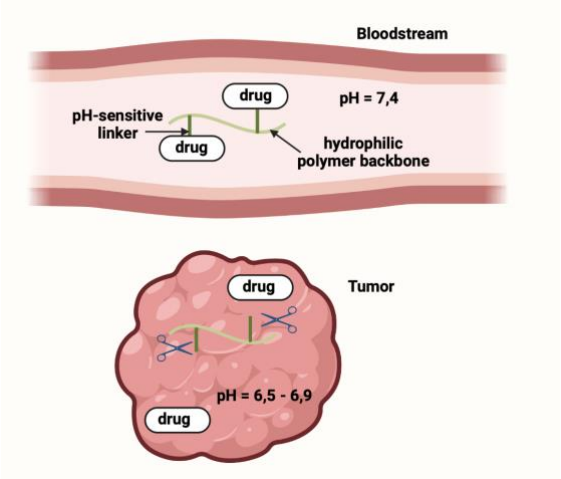

Figure 1: Mechanism of action of the polymeric drugs. Drug is covalently attached to the polymeric carrier via hydrazone bond which is stable during circulation in the bloodstream. However, the pH-sensitive hydrazone bond is hydrolyzed due to the lower pH in tumor interstitium (slowly) or upon endocytosis in endosomes and lysosomes of cancer cells (fast process) and drug is released in controlled manner.

Acknowledgement:
This work was supported by the project National Institute for Cancer Research (Programme Exceles, ID Project No. LX22NPO5102) – Founded by the European Union – Next Generation EU)

Inhibition of P-gp mediated multidrug resistance and STAT3 signaling pathway by polymeric conjugates bearing HIV protease inhibitor derivatives

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[*] presenting author e-mail address: daniil.starenko@biomed.cas.cz

Abstract: Drug delivery systems based on synthetic polymeric carriers are promising tools for development of new drugs studied world-wide. Using polymeric drug delivery system is a promising strategy to improve properties of chemotherapeutic agents used for treatment of cancer. *N*-(2-hydroxypropyl)methacrylamide (HPMA) based polymer-drug conjugates can prolong blood circulation half-life, lower side toxicities and provide higher accumulation of anticancer drug in the tumor tissue. Utilization of pH-sensitive hydrazone bond enables controlled drug release from the carrier in the lower pH of tumor microenvironment or within endosomes/lysosomes upon endocytosis. Multidrug resistance (MDR) is one of the key problems in chemotherapy of cancer. Tumors with MDR are not susceptible to the cytostatic/cytotoxic action of many even structurally different drugs. Certian compounds known as chemosensitizers can reverse MDR. In this study we evaluated HPMA copolymer-based conjugate bearing the derivative of HIV protease inhibitor lopinavir (LD; obtained by esterification with 5-methyl-4-oxohexanoic acid) as a potential chemosensitizer. We studied the ability of the conjugate to inhibit P-glycoprotein, one of the most common ABC transporter responsible for the drug efflux in MDR. Further, we studied also the potential of LD to inhibit STAT3 signaling pathway, which constitutive activation may contribute to MDR in some tumors. LD was found to be potent inhibitor of both P-glycoprotein and STAT3 phosphorylation and chosen for further investigation. We tested the chemosensitizing potential of the conjugate bearing LD in combination with conventional cytostatics (doxorubicin, docetaxel and mitoxantrone) and their HPMA copolymer-based conjugates and found significant increase in cytostatic and cytotoxic activity. Finally, we studied the toxicity and antitumor activity of combination of the polymeric conjugates bearing doxorubicin and lopinavir derivative *in vivo*. We observed that such combined therapy led to considerable reduction of P388/MDR tumor growth at the dosage showing low toxicity.

Keywords: HPMA copolymer-drug conjugates, multidrug resistance, cytostatic drug, P-gp inhibition.

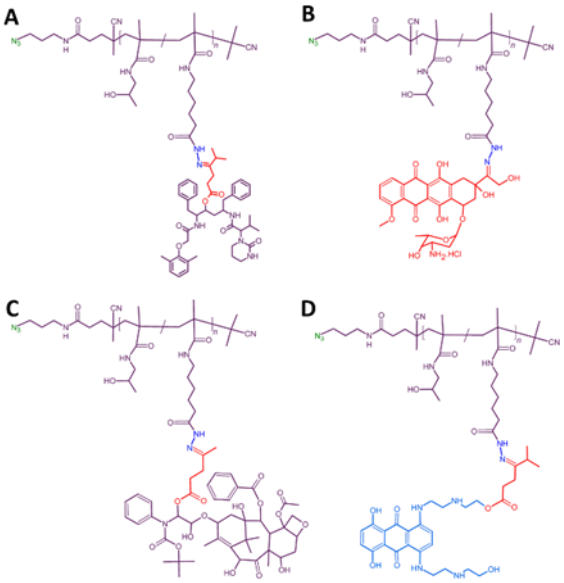

Figure 1: Chemical structure of used HPMA copolymer-based polymeric conjugate bearing (A) lopinavire derivative, (B) doxorubicine (C) docetaxel derivative and (D) mitoxantrone derivative bound by pH-sensitive hydrazone bond (in blue).

Acknowledgement: This work was supported by the project National Institute for Cancer Research (Programme Exceles, ID Project No. LX22NPO5102) – Founded by the European Union – Next Generation EU.

Multiphoton imaging of melanoma 3D models and photothermal therapy in chemoresistant melanoma with plasmonic gold nanocapsules

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[4] Instituto Ramón y Cajal de Investigación Sanitaria, Madrid, Spain

Abstract:
We report the synthesis of plasmonic nanocapsules and the cellular responses they induce in 3D melanoma models for their perspective use as a photothermal therapeutic agent. The nanocapsules exhibit simultaneous two-photon luminescent, fluorescent properties, X-ray contrasting ability, and bioimaging ability of models such as 3D spheroids with complex architecture. Their multimodal imaging properties are exploited for the first time to study tumorspheres cellular responses exposed to the nanocapsules. in 3D melanoma models, we confirmed the maintenance of the nanocapsules' geometry in the intracellular milieu with no impairment of the cellular ultrastructure. Furthermore, we observed the lack of cellular toxicity and no alteration in oxygen or reactive oxygen species levels. Based on these, the nanocapsules were tested for multiphoton luminescence-assisted photothermal therapy in chemoresistant melanoma models. The response of nanocapsules upon near-infrared excitation was studied in 2D and 3D cell cultures and in vivo melanoma models. In cell cultures, a transient increase in oxidative stress levels, induction of apoptosis and cellular ablation were observed by adjusting the thermal dose. In vivo, single-photon excitation at 806 nm of gold nanocapsules administered intratumorally in subcutaneous melanoma tumors leads to a complete ablation of the tumor. Ulterior ex vivo analysis of mice by ICP-MS characterizes the distribution of gold nanocapsules in vivo. These results highpoint the potential of gold nanocapsules as photoresponsive agents for the photothermal therapy of melanoma.

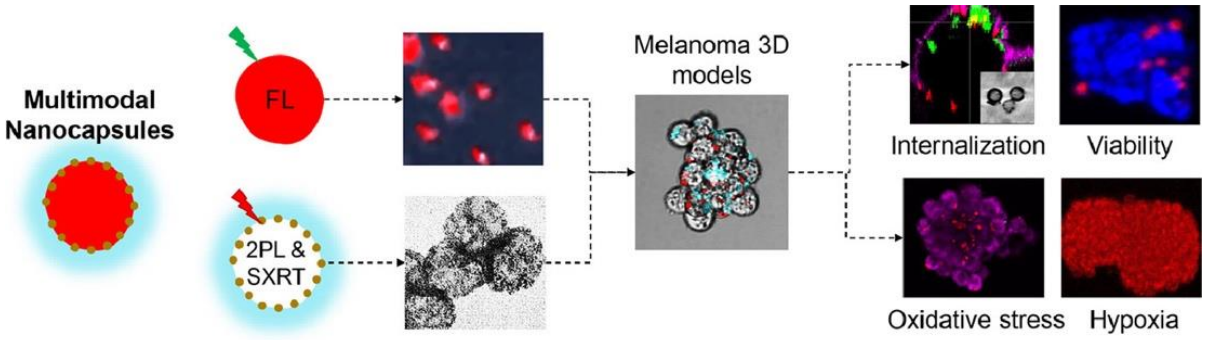

Figure 1. Multiphoton imaging of melanoma 3D models with plasmonic nanocapsules

Keywords: Plasmonic gold biocompatible nanocapsules, Two-photon luminescence, X-ray tomography, Fluorescence lifetime, Nanoparticle cell interactions, 3D tumorspheres, Melanoma cancer, Bioimaging, Reactive oxygen species (ROS), Hypoxia, Photothermal therapy

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A new 7-(diethylamino)coumarin and 4-(diethylamino)phenol appended unsymmetrical thiocarbohydrazone: detection of moisture in organic solvent and sequential turn-on detection of Cu^{2+} ions

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[2] Department of Polymer Chemistry and Technology, Kaunas University of Technology, Radvilenu Plentas 19, LT-50254, Kanuas.

Abstract:

A novel 7-(diethylamino)coumarin and 4-(diethylamino)phenol appended unsymmetrical thiocarbohydrazone (DCDP) was designed and synthesized. The DCDP forms an interesting three dimensional hydrogen bonded network that results in an interesting supramolecular network. The compound showed fluorometric and colorimetric response towards fluoride anion via deprotonation process due to the presence of phenolic -OH and -NH groups. The anionic species DCDP-F^- was successfully employed for the detection of moisture in organic solvents through the reprotonation process. The synthesized probe DCDP exhibits highly selective and sensitive detection for Cu^{2+} ions. The DCDP-Cu^{2+} ensemble might be used as a highly selective sensor for Cysteine (Cys) in the presence of other amino acids without any interference. Further, the potential reversible sensing feature of Cu^{2+} and Cys by DCDP were recognized to develop the INHIBIT logic gate function and on-site detection of Cu^{2+} ions and Cys by a paper strip applications.

Keywords: Unsymetrical thiocarbazone, moisture detection, turn-on copper detection, cysteine reversibility, INHIBIT logic gate function.

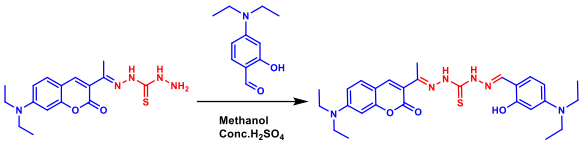

Figure 1: Synthesis of unsymmetrical compound (DCDP).

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Design and Evaluation of an Energy-autonomous Ultra-thin Wireless Sensor Node for Condition Monitoring of Wind Turbine Blades

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Abstract:
Wind turbines are installed in remote locations and are exposed to harsh environmental conditions, which have a particularly strong impact on their rotor blades. Therefore, it is of great interest to acquire local measurement data to determine the present state of the wind turbine to enable safe and efficient operation.
For this purpose, we present an energy-autonomous, ultra-thin wireless sensor node. The sensor node consists of a planar capacitive sensor for ice layer detection and MEMS accelerometers for eigenfrequency analysis in regular intervals and continuous peak load detection. The energy-autonomous operation is obtained with a thin-film solar cell designed for low illumination, a constant voltage charging circuitry and a bendable Li-Ion technology EnerCera® from NGK with a height of 450 µm as energy storage. The operational components of the sensor node are evaluated independently and the wireless sensor system is demonstrated on a small-scale wind turbine blade with a nominal output power of less than 1 kW.

Keywords: wireless sensor node, energy-autonomous, energy harvesting, flexible electronics, predictive maintenance, wind turbine monitoring, eigenfrequency analysis, MEMS accelerometers, ice layer detection, capacitive sensor.

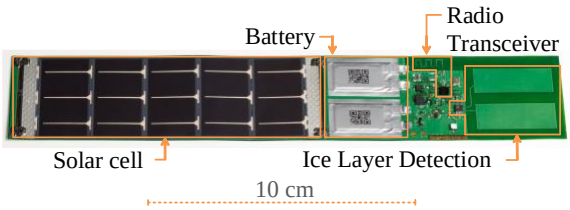

Figure 1: Photo of the energy-autonomous wireless sensor node of the semi-flexible electronics on a 200 µm thick polyimide substrate.

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How to deal with low cost air quality sensors? – experiences from the project “Do you know what you breathe?” – educational and information campaign for cleaner air LIFE-MAPPINGAIR/PL

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Abstract:
According to the European Environmental Agency, 413,000 premature deaths in the European Union are linked to exposure with fine particulate matter ($PM_{2.5}$), 136,000 premature deaths due to nitrogen dioxide (NO_2) and 107,000 premature deaths due to ozone (O_3). In Central European countries (especially Poland), there is a particular problem with high $PM_{2.5}$ concentrations in the winter season, related to the widespread use of solid fuels in the household sector. This problem has now become an important element of public discourse, and the public's demand for reliable, “here and now” information on air quality has significantly increased. It is supported by rapidly developing tools and concepts enabling such access (mobile technologies, Internet of Things, smart cities idea, etc.) and EU programs such as DIGITAL supporting universal access to information, e.g. in the context of achieving the assumptions of the Green Deal.

Such information is not provided by professional systems operated by government agencies (relatively few stations in the network in given area). Currently, an alternative to them are networks based on low-cost sensors. Such sensors, especially those used to measure PM concentrations, have become more popular in recent years. A manifestation of this trend is the emergence of commercial and non-commercial (including scientific) measurement networks that provide data on air quality parameters with high spatial and temporal resolution. Unfortunately, the use of these devices also has weaknesses related to technical aspects as well as methodological issues (proper location of measurement stations, correct presentation of data).

To deal with these problems, as part of the LIFE-MAPPINGAIR/PL project, implemented by the University of Wrocław, Wrocław University of Science and Technology and the Bydgoszcz City Hall, it was planned to build a measurement network consisting of 40 low-cost sensors measuring PM concentrations in Wrocław and Bydgoszcz agglomerations (Poland). This network, in addition to its information function, was intended as demonstrator of good practices in the use of low-cost sensors. The basic assumption adopted when creating the system was that the selection of sensors and the construction of measuring devices, their calibration and the location of measurement stations would be carried out according to the specifications developed by the Project team, based on the results of previous research on low-cost solutions, conducted by the team of the Department of Climatology and Atmospheric Protection of the University of Wrocław, in cooperation with the Wrocław University of Science and Technology. The devices constructed for this purpose use set two types of optical PM sensors - Plantower PMS7003 and Sensirion SPS30 (wchich provide ensemble results) and the O_3 SM50 sensor from Aeroqual, supported by air temperature and humidity sensors, used, among others, to maintain appropriate humidity parameters in the heated measurement path. The correct operation of the sensors was verified based on higher-level measuring devices operating at the Meteorological Observatory of the University of Wrocław. The network was launched operationally in September 2021, measurement results are presented on the website https://airquality.uni.wroc.pl.

This study presents experiences and conclusions related to the implementation and operational use of the created measurement network, including the assessment of its use in information and educational activities addressed to local communities.

Keywords: air quality, particulate matter, low-cost sensors, measurements prtagmatics, data sharing, education, information, free data

Structure and bioactive properties of titanium dioxide surface layers produced on NiTi shape memory alloy in low temperature plasma

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Abstract:
NiTi alloy pertains to the emerging category of "smart materials" and is experiencing growing significance within the field of medicine, primarily attributable to its distinctive attributes, such as shape memory and superelasticity [1,2]. However, its use for long-term use implants requires improvement of biocompatibility due to its high nickel content. The surface treatments should make it possible to control the properties of the produced layers and not affect the mechanical properties of the alloy, which can be achieved by low temperature processes. Such requirements are met by the processes under glow discharge conditions in low temperatures plasma [3].
Therefore, in this work, we propose the surface modification of NiTi shape memory alloy by oxidizing in a low-temperature plasma under glow discharge conditions. We describe the effect of
different process parameters, such as temperature, time, as well as method of preparing the sample surface (mechanical grinding and polishing) on the structure of produced surface layers. We also demonstrate how the differences in the technological parameters of the processes carried out and the resulting titanium oxide structures influenced the surface properties, such as surface topography, surface morphology, its chemical composition, its wettability and surface free energy, as well as bioactivity, understood as the ability to biomimetic deposition of calcium phosphate while incubating in the simulated body fluid (SBF) solution. The methodology includes research using transmission electron microscopy (TEM), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), optical profilometer, optical goniometer. The bioactivity of the produced surface layers was examined by microscopic evaluation of the apatite deposits formed on the surface of oxidized layers in comparison to the NiTi alloy in its initial state.
The proposed surface modification of NiTi shape memory alloy by oxidizing conducted at low-temperature plasma resulted in the formation of titanium oxide TiO_2 surface layers. The resulting layers had thicknesses ranging from about 50 to 150 nm and had a mostly nanocrystalline structure, and the dominant form of titanium oxide was rutile. A clear relationship was noticed between the extended process time and the increase in thickness, but it is not a linear relationship. After some time, the layer stops growing and even extending the time to 8 hours does not result in a layer thicker than 200 nanometers. Also, an increase in temperature to 390 degrees causes the formation of a thicker layer, but this also affects its structure, which is different from the one formed at 290 degrees and contains more precipitates and inhomogeneities visible in cross-sections in the bright field TEM images. It was also shown that the formed layers increase the bioactivity of the NiTi alloy tested after 14 and 30 days of incubation in SBF solution.
Low temperature plasma oxidizing process allows the production of bioactive surface layers composed of titanium oxide whose structure and properties can be controlled by process parameters. This may be a way to increase the biocompatibility of the NiTi shape memory alloy in the aspect of medical implants.

Keywords: NiTi shape memory alloys, glow discharge oxidizing, structure, biocompatibility, bioactivity

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In Vitro Superparamagnetic Hyperthermia Employing Magnetite Gamma-Cyclodextrin Nanobioconjugates for Squamous Skin Carcinoma Therapy

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Abstract:

In vitro alternative therapy of human squamous cancer (A431) by superparamagnetic hyperthermia (SPMHT) using Fe_3O_4 (magnetite) superperamagnetic nanoparticles (SPIONs) with an average diameter of 15.8 nm bioconjugated with hydroxypropyl-gamma-cyclodextrins (HP-γ-CDs) by means of polyacrylic acid biopolymer (PAA), is presented in this paper. The therapy was carried out at a temperature of 43 °C for 30 min. using the concentrations of Fe_3O_4 ferrimagnetic nanoparticles from nano-bioconjugates of 1, 5 and 10 mg/mL nanoparticles in cell suspension, which were previously found by us [1] to be non-toxic for healthy cells (cell viabilities close to 100%), according to ISO standards (cell viability >70%) [2]. The temperature for in vitro therapy was obtained by the safe application (without exceeding the biological limit and cellular damage) [3] of an alternating magnetic field with a frequency of 312.4 kHz and the amplitudes of 168, 208, 370 Gs, depending on the concentration of the magnetic nanoparticles. The optimal concentration of magnetic nanoparticles in suspension was found experimentally. The results obtained after the treatment show a high effectiveness in destroying the A431 tumor cells, up to 83%, with the possibility of increasing it even more, which demonstrates the viability of the SPMHT method with Fe_3O_4-PAA–(HP-γ-CDs) nano-bioconjugates for alternative cancer therapy.

Keywords: alternative therapy, super-paramagnetic hyperthermia, *in vitro*, human epidermoid squamous carcinoma, magnetite-gamma-cyclodextrins, nanobioconjugates.

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Determinants and consequences of PARG inhibitor sensitivity in ovarian cancer; a proteomics approach

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Abstract:
Ovarian cancer is the eight most common cancer in women around the world. Treatment options are limited to surgery and cytotoxic chemotherapy[1]. More recently, PARP inhibitors have shown to be very effective in patients with HR-deficient disease. However, at most ~40% of cases are HR-deficient, leaving the majority of ovarian cancer patients in need of alternative therapeutic options[2]. We recently showed that a subset of ovarian cancer cell lines and patient-derived models are sensitive to inhibitors targeting PARG, the glycohydrolase that counterbalances PARP activity[3]. However, why some ovarian cancer cells are sensitive and other resistant remains a mystery. In an effort to better understand the molecular determinants of PARG inhibitor sensitivity, I have taken an unbiased proteomic- based approach. In brief, I have analysed a panel of cell lines with defined PARGi sensitivity using Liquid Chromatography–Mass Spectrometry (LC-MS) to generate a multi-layered proteomic signature. A total of 6215 proteins were detected in all ovarian cell line and 299 of those proteins were differentially expressed in PARGi sensitive cell lines. The next phase will be a functional screen using siRNA-mediated repression of the differentially expressed proteins to determine if they modulate PARGi sensitivity. This data will hopefully provide insight into the molecular determinants of PARGi sensitivity and in turn guide the development of predictive biomarkers for PARGi sensitivity.

Keywords: Ovarian Cancer, PARG inhibitors, Proteomics

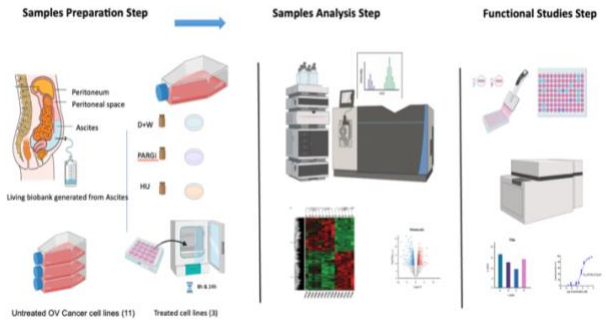

Figure (1): Schematic workflow for the experimental plan.

A) in this step, we used three types of samples (patients samples, untreated and treated cell lines). A living biobank for ovarian cancer models was developed by the lab by Dr. Louisa Nelson (Nelson *et al.,* 2020). Ovarian cancer cell lines (Kuramochi and COV318) and FNE treated with PARGi
B) All samples both *in vitro* and patients cancer cells were ran in a high-throughput liquid chromatography tandem mass spectrometry (LC/MS/MS) methodology to compare our cohort to the build-up proteomic library in the database.
(C) Our strategy is to test the top proteins identified based on the reading outcome using different functional analyses

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