NANOTECH FRANCE 2024 / GAMS 2024 / NANOMATEN 2024 / BIOTECH FRANCE 2024

Joint International Conferences and Exhibition

05 - 07 June 2024

Paris – France

Book of Abstracts

Organizer

SETCOR
Conferences & Exhibitions

Nanotech France 2024 / GAMS 2024 / NanoMatEn 2024 / Biotech France 2024
Joint Conferences Program
05 - 07 June 2024, Paris, France

June 05, 2024		
09:00 - 12:00	**Onsite Participant registration**	
09:30 - 10:30	**Morning Coffee Break**	
Nanotech France / GAMS/ Biotech France 2024 Joint Plenary session		
Amphithéâtre		
Session's Chairs: **Dr. Alba Garzón Manjón, Catalan Institute of Nanoscience and Nanotechnology, Spain** **Prof. Alexander Mukasyan, University of Notre Dame- Indiana, USA**		
10:30 - 11:00	Epitaxial Growth of Silicene : Successes and Challenges. **L. Masson**	**Prof. Laurence Masson**, Aix-Marseille University, **France**
11:00 - 11:30	Micro- and Nanorobots: From single agents to microelectronic morphogenesis. **O. G. Schmidt**	**Prof. Oliver Schmidt**, Chemnitz University of Technology, **Germany**
11:30- 12:00	The sythesis of bio-based nanocomposites by an in-situ processing and consolidation method. **R. Tannenbaum**	**Prof. Rina Tannenbaum**, Stony Brook University, **USA**
12:00 - 14:00	**Lunch Break**	
Nanotech France / GAMS 2024 Joint Session I.A: **Nanomaterials Fabrication / Synthesis / properties**		
Amphithéâtre		
Session's Chairs: **Prof. Laurence Masson, Aix-Marseille University, France** **Dr. Alberto Bianco, CNRS/ University of Strasbourg, France** **Dr. Vinod Paidi, European Synchrotron Radiation Facility- Grenoble, France**		
14:00 - 14:30	Solution Combustion Synthesis of Nanomaterials: Recent Advances. **A.S. Mukasyan**	**Prof. Alexander Mukasyan**, University of Notre Dame- Indiana, **USA**
14:30 - 15:00	Novel Cyclodextrin-Based Supramolecular Polymers for Nanomedicine and Environmental Sustainability Applications. **J. Li**	**Prof. Jun Li**, National University of Singapore, **Singapore**
15:00 - 15:15	Synthesis of Ultra-Small Gold Nanostars for Applications in Catalysis, Sensing and Photothermia. **E.S. Abu Serea**, L.B. Berganza, S. Lanceros-Méndez and J. Reguera	**Mrs. Esraa S. Abu Serea Sewlam**, Basque Center for Materials, Applications, and Nanostructures, **Spain**
15:15- 15:30	Preparation and characterization of different type of aligned Cellulose nanofiber. **F. Mohtaram** and P. Fojan	**Ms. Fatemeh Mohtaram**, Aalborg University, **Denmark**
15:30 - 15:45	Synthesis and Self-Assembly of Titania Nanoplatelets and Their Encapsulation in a Polystyrene Shell via Photocatalytic Surface-Grafted Radical Polymerization. **J. Struck**, B. Sochor and T. Vossmeyer	**Ms. Jana Struck**, University of Hamburg, **Germany**
15:45 - 16:00	Automated dry synthesis and deposition of nanomaterials. **V. Mazzola**, T. Pfeiffer and A. van Vugt	**Mr. Vincent Mazzola**, VS Particle, Delft, **The Netherlands**
16:00 - 16:30	**Afternoon Coffee Break**	
Session's Chairs: **Prof. Laurence Masson, Aix-Marseille University, France** **Dr. Alberto Bianco, CNRS/ University of Strasbourg, France** **Dr. Vinod Paidi, European Synchrotron Radiation Facility- Grenoble, France**		

16:30 - 16:45	Highly Magnified Dimer Sputtering and Nanoparticle Generation via Pulsed Magnetron Discharge. **P. Curda**, R. Hippler, M. Cada, O. Kylián, Z. Hubicka and V. Stranak	**Mr. Pavel Curda**, University of South Bohemia, **Czech Rep.**
16:45 - 17:00	Sinter- and Binder-based processing of Mg-alloy AZ41 by MIM (Metal Injection Moulding) reinforced by AlN-nanoparticles. **M. Wolff**, T. Ebel and R. Willumeit-Römer	**Mr. Martin Wolff**, Helmholtz-Zentrum Hereon, **Germany**
17:00 - 17:15	Self-Assembly Approach for the Fabrication of Multi-Level Bio-Inspired Magnetic Nanocomposites. **L. R. Klauke**, M. Kampferbeck, F. C. Klein, P. Haida, B. Sochor, A. Meyer, V. Abetz and T. Vossmeyer	**Ms. Lea Klauke**, University of Hamburg, **Germany**
17:15 - 17:30	Unlocking TiO2's Nanomagnetism: Oxygen Vacancies Lead the Way. **V.K. Paidi**, B.-H. Lee, A.T. Lee, S. Ismail-Beigi, E. Grishaeva, S. Vasala, P. Glatzel, W. Ko, D. Ahn, T. Hyeon, Y. Kim and K.-S. Lee	**Dr. Vinod Paidi**, European Synchrotron Radiation Facility- Grenoble, **France**
17:30 - 17:45	Functionalization of natural zeolite Clinoptilolite with AgNPs via green in situ reduction. **F. Gattucci**, M. Lallukka, N. Grifasi, M. Piumetti and M.Miola	**Ms. Francesca Gattucci**, Politecnico di Torino, **Italy**
17:45 - 18:00	The internal photoluminescence quantum yield and radiative lifetimes of silicon quantum dots. **K. Kusova**, T. Popelar, P. Galar, F. Matejka and J. Kopenec	**Dr. Katerina Kusova**, Czech Academy of Sciences- Prague, **Czech Rep.**
18:00 - 18:15	Tailoring Color Appearance with Tunable Disordered Metafilms. **J. Peng**, H. Wu, W. Xu, B. Yang and Z. Zhu	**Dr. Jialong Peng**, National University of Defense Technology, **China**

June 05, 2024		
Nanotech France 2024 / GAMS 2024 Joint session I. B: Nanomaterials Characterization and Properties		
Conference Room Derain 1-2		
Session's Chairs: Prof. Julio Sanchez, University of Santiago, Chile Dr. Henry Cardenas, Louisiana Tech University, USA Prof. Bonamali Pal, Thapar Institute of Engineering and Technology, India		
14:00 - 14:30	Insights into the degradation mechanisms of nanocatalysts through correlative STEM analysis. **A. Garzón Manjón**	**Dr. Alba Garzón Manjón**, Catalan Institute of Nanoscience and Nanotechnology, **Spain**
14:30 - 14:45	A Novel Memristor Design based on Hydrogen Movement on Silicon Surfaces. N. N. Nipu and **P. Schubert**	**Prof. Peter Schubert**, Indiana University-Purdue University Indianapolis, **USA**
14:45 - 15:00	Scalar topological photonic meta-crystals **B. Yang**	**Prof. Biao Yang**, National University of Defense Technology, **China**
15:00 - 15:15	Microstructural Effects of Microballistic Impact on Nacre-Like Graphene-Polyethylene Nanocomposites: Exploring the Influence of Hierarch. **P. Punj Singh** and R. Ranganathan	**Mr. Param Punj Singh**, Indian Institute of Technology Gandhinagar, **India**
15:15 - 15:30	Antibacterial and Photocatalytic Properties of Hydrothermally Synthesized ZnO Nanowires. **S. Abou Zeid**, A. Perez, S. Rossano and Y. Leprince-Wang	**Dr. Souad Abou Zeid**, Gustave Eiffel University, **France**
15:30 - 15:45	Metabolomic Pathways of an Acrylic Resin Enriched with AgNPs as a Proposal for Orthopedic Aparatology. **C.A. Lopez-Ayuso**, H. Sakagami, M. Sugimoto, R. Garcia-Contreras, R. Manisekaran, M. Figueroa, M. Rangel-Grimaldo and L.S. Acosta-Torres	**Mr. Christian A. Lopez-Ayuso**, National Autonomous University of Mexico, **Mexico**
15:45 - 16:00	Nonlinear Optical Properties of Two-Dimensional Materials – A Study on their Suitability for Laser Protection Applications. **S. Dengler** and M. Henrichsen	**Ms. Stefanie Dengler**, Fraunhofer IOSB, **Germany**
16:00 - 16:30	**Afternoon Coffee Break**	
Session's Chairs: Dr. Stefanie Dengler, Fraunhofer IOSB, Germany Prof. Julio Sanchez, University of Santiago, Chile Prof. Bonamali Pal, Thapar Institute of Engineering and Technology, India		
16:30 - 16:45	Analytical Prediction of Nanoparticle Traffic Jams during Electroketic Treatment of Hardened Concrete. H. Zhong and **H. Cardenas**	**Dr. Henry Cardenas**, Louisiana Tech University, **USA**
16:45 - 17:00	Smaller pattern size increase mechanical performance and improves stress distribution in parts designed using 3D mass reduction method bio-inspired from trabecular form-function relationship. **N. Cadoret**, J. Chaves-Jacob, M.-A. Celli and J.-M. Linares	**Mr. Nicolas Cadoret**, Airbus Helicopters/ Aix Marseille University, **France**
17:00 - 17:15	X-Ray Fluorescence Imaging and Defect Cluster Map Enhancement in Metal Photopolymer Nano-Composite Thin Film. **M. Arya**, A. Yella, G. Kuma, S.R. Kasture, Ch. Vandana, A. Kumari, B R Sanjeeva Reddy, P.V. Kalluru, S. Madugula and S.P Duttagupta	**Dr. Meenakshi Arya**, Indian Institute of Technology Bombay, **India**
17:15 - 17:30	Passive silicon optical isolator based on free carrier dispersion effect. **W. Xu**, Q. Hong, G. Xia, P. Xu and Z. Zhu	**Dr. Wei Xu**, National University of Defense Technology, **China**.
17:30 - 17:45	Opuntia Ficus-indica extraction based anticounterfeiting tag functioning at Optical and Terahertz band. **S. K. Sighano**, T. Ritacco, M. D. L. Bruno, O. Gennari, W. Fuscaldo, D.C. Zografopoulos, R. Beccherelli, T. Maurer, R. Caputo and A. Ferraro	**Ms Sephora Kamwe Sighano**, Technology University Troyes, **France**

17:45 - 18:00	Quantifying Microstructural Evolution in Cyclically Loaded NiTi SMAs: Advancing Fatigue Criterion through Stored Energy Analysis. **X. Ju**, Z. Moumni and A. Borbely	**Dr. Xiaofei Ju**, Nanyang Technological University, **Singapore**
18:00 - 18:15	Exploring the use of GaAsBi alloys as strain-reducing layers in InAs/GaAs QDs. **S. Flores**, D. F. Reyes, V. Braza, T. Ben, N.J. Bailey, M.R. Carr, R.D. Richards and D. Gonzalez	**Mrs. Sara Flores**, The University of Cadiz. **Spain**.

June 05, 2024

Nanotech France / Biotech France 2024 Joint session I.C

Conference Room Dufy

Session's Chairs:
Prof. Rina Tannenbaum, Stony Brook University, USA
Dr. Giorgia Urbinati, CNRS/ Gustave Roussy Cancer Campus, France

14:00 - 14:30	Mechanobiological effects of geometry-mediated wound healing **K. Jimmy Hsia** and H. Xu	**Prof. K Jimmy Hsia**, Nanyang Technological University, **Singapore**
14:30 - 14:45	Development and Characterization of New Chitosan-Based Nano-fibers for Wound Management. **L. Profire**, O.M. Ionescu, A.T. Iacob, F.G. Lupascu, B.S. Profire, S.E. Giusca and I.D. Caruntu	**Prof: Lenuta Profire**, "Grigore T. Popa" University of Medicine and Pharmacy from Iasi, **Romania**
14:45 - 15:00	Reusable lithium-free multilayer MXene based sorbents for portable dialysis cartridges. **E. Precetti**	**Mr. Eliot Precetti,** Drexel University, **USA**
15:00 - 15:15	Synthesis and investigation of properties of conductive nanocomposites for nerve regeneration applications. **A. Sierakowska-Byczek**, J. Radwan-Pragłowska, Ł. Janus and J. Śmietana	**Mrs. Aleksandra Sierakowska-Byczek**, Cracow University of Technology, **Poland**
15:15 - 15:30	Magnesium based bulk metallic glasses for biomedical applications. **R. Kumari rajendran**, D. Aggarwal, M. Roland, C. Gruescu, R. Shabadi	**Mr. Rajesh Kumari Rajendran**, University of Lille, **France**
15:30 - 15:45	Use of an Innovative Material for Biotech Applications in Agriculture. M. Rippa, E. Lahoz, M. Cermola, P. Mormile and V. Battaglia	**Dr. Ernesto Lahoz**, CREA - Research Centre for Cereal and Industrial Crops, **Italy**
15:45 - 16:00	Methane conversion into methanol by M. trichosporium OB3b: Investigating the bioprocess limitations and solutions. **H. Baldo**, A. Ruiz Valencia, L. Cornette de Saint Cyr, E. Petit, J. Sanchez-Marcano, M.P. Belleville, L. Soussan	**Ms. Héloïse Baldo**, Univ. Montpellier, **France**
16:00 - 16:30	**Afternoon Coffee Break**	
16:00 - 16:15	Phenolic content of orange sweet potato flour influenced by ultrasound pretreatment, cold storage, and drying technologies. **A. Gomez-Cisneros**, M. Calderon-Oliver, L. Santos-Zea and A. Escalante-Alburto	**Ms. Analaura Gómez-Cisneros**, Tecnologico de Monterrey, **Mexico**
16:15 - 16:30	Unraveling the Disaggregating Potential of Natural C20 Carotenoids on $A\beta_{1-42}$ and Tau Fibers. **S. Z. Bathaie**	**Prof S. Zahra Bathaie**, Tarbiat Modares University, **Iran**

June 06, 2024

Nanotech France/ GAMS/ Biotech France 2024 Joint Plenary session II

Amphithéâtre

Session's Chairs:
Prof. Elisabetta Esposito, University of Ferrara, Italy
Prof. Rina Tannenbaum, Stony Brook University, USA
Prof. Eliana Leo, University of Modena and Reggio Emilia, Italy

09:00 - 09:30	Materials for Eco-Design Strategies for an Innovative Industry. **R. Martins**, S. Nandy, P. Barquinha, L. Pereira, T. Pinheiro, H. Almeida, R. Igreja, E. Carlos and E. Fortunato	**Prof. Rodrigo Ferrão de Paiva Martins**, Nova Univ. of Lisbon, **Portugal**
09:30 - 10:00	Applications of direct-write nanoscale materials in Nanotechnology. **J.M. De Teresa Nogueras**	**Prof. José María De Teresa Nogueras,** CSIC-University of Zaragoza, **Spain**
10:00 - 10:30	The Toxicology of Inhaled Particles and Examples of Risk Assessment and Regulation. **U. B. Vogel**	**Prof. Ulla Birgitte Vogel,** Technical University of Denmark, **Denmark**
10:30 - 11:00	**Morning Coffee Break**	
11:00 - 11:30	Lung fate and biotransformation of exfoliated MoS2. **A. Bianco**	**Dr. Alberto Bianco,** CNRS/ University of Strasbourg, **France**
11:30 - 12:00	Blood-brain barrier-on-a-chip as a suitable platform to evaluate gold nanoparticles against Alzheimer's disease. **A. Tapia-Arellano**, S. Palma-Florez, P. Cabrera, E. Cortés-Adasme, K. Bolaños, R. Aldunate, N. Hasan, M. J. Kogan, **J. Samitier**, A. Lagunas and M. Mir	**Dr. Andreas Tapia Arellano**, Institute for Bioengineering of Catalonia- Barcelona, **Spain**
12:00 - 12:30	Exploiting New Strategies to Deliver an Old Drug. **B. Stella**	**Dr. Barbara Stella**, University of Turin, **Italy**
12:00 - 14:00	**Lunch Break**	

Group Photo at 13:45

NanoMatEn / GAMS Joint Session II.B:
Materials and Nanomaterials for Energy / Nanoelectronics/ Nanophotonics

Amphithéâtre

Session's Chairs:
Prof. Rodrigo Ferrão de Paiva Martins, Nova University of Lisbon, Portugal
Dr. Raul Arenal, University of Zaragoza, Spain

14:00 - 14:15	From Lab to Pilot: VTT's Advances in Sustainable Cellulose Film and Coating Technologies. V. Kumar, V. Kunnari, **H. Ahadian**, A. Khakalo, A. Jaiswal, P. Ahokas, A. Sonker, A.Yamamoto	**Mr. Hamidreza Ahadian**, VTT Technical Research Centre, **Finland**
14:15 - 14:30	An innovative strategy to fabricate wrinkled silver-based nanoporous material combining plasma-based technique and dealloying process. **R. Dantinne**, A. Chauvin, S. Asaram Raut, P. Leclere, C. Poleunis, A. Delcorte, R. Snyders and D. Thiry	**Mr. Robin Dantinne**, University of Mons, **Belgium**
14:30 – 14:45	Development of Fluorine-Free Superhydrophobic Surfaces combining Plasma Polymerization and the wrinkling approach. **S. Asaram Raut**, R. Dantinne, R. Snyders and D. Thiry	**Dr. Suyog Asaram Raut**, University of Mons, **Belgium**
14:45 -15:00	Unraveling the Potential of Non-Thermal Plasma in the Synthesis and Surface Tailoring of Silicon Nanoparticles. **F. Matejka**, J. Kopenec, P. Galar, T. Popelar and K. Kusova	**Mr. Filip Matejka**, University of Chemistry and Technology- Prague, **Czech Rep.**
15:00 - 15:15	Sequenced plasma electrolytic oxidation of aluminium alloys: a tool to control the coating porosity. **L. Magniez**, S. Fontana, J. Martin, C. Hérold and G. Henrion	**Mr. Lucas Magniez**, University of Lorraine - CNRS, **France**

15:15 - 15:30	Investigation the effect of applied voltage on the modification of surface roughness of materials after plasma electrolytic polishing. **N. Truong Son**, L. Magniez, J. Martin, G. Henrion and F. Girard	**Dr. Nguyen Truong Son**, University of Lorraine-CNRS, **France**
15:30 - 15:45	Aerosol Assisted Chemical Vapor Deposition of Copper Sulfide films with sensitivity to NO2. **H. Trabelsi**, I. Gràcia, K. Alouani and **S. Vallejos**	**Mrs. Houyem Trabelsi**, Institute of Microelectronics of Barcelona (IMB-CNM, CSIC), **Spain**
15:45 - 16:00	Modulation of Spin and Charge Currents Through Functionalized 2D Diamond and Few-layer Boron Nitride Devices. E. E. de Moraes,A. A. Pinto, R. J. C. Batista, A. B. de Oliveira and **H. Chacham**	**Prof. Helio Chacham**, Federal University of Bahia, **Brazil**
16:00 - 16:30	**Coffee Break**	
Session's Chairs: **Prof. Fu-Ming Wang, National Taiwan University of Science and Technology, Taiwan** **Dr. Suyog Asaram Raut, University of Mons, Belgium**		
16:30 - 17:00	1D Nanomaterials – Detailed Nanoscopic Investigations. **R. Arenal**	**Dr. Raul Arenal**, University of Zaragoza, **Spain**
17:00 - 17:15	Biopolymeric Nanofibers Functionalized with Quiral Cyclodipeptides for Energy Harvesting. **D. Santos**, R. Baptista, E. de Matos Gomes and B. Almeida	**Ms. Daniela Santos**, University of Minho, **Portugal**
17:15 - 17:30	Enhanced performance of Li-ion battery electrodes protected by atomic layer deposited oxide films. **K. Frohlich**, P. Sahoo, A. Güneren and B. Hudec	**Dr. Karol Frohlich**, Slovak Academy of Sciences, **Slovakia**
17:30 -17:45	Unveiling the Potential of Textile Beeswax Triboelectric Nanogenerators for Sustainable Energy Processing. **E. Kovalska**, H. T. Lam, Z. Saadi, R. Mastria, A.I.S. Neves, S. Russo and M.F. Craciun	**Dr. Ievgeniia Kovalska**, University of Exeter, **UK**
17:45 -18:00	Stability of inorganic perovskites nanocrystals: what is at the end of the tunnel?. **P.K. Mubiayi**	**Dr. Pierre Kalenga Mubiayi**, University of Witwatersrand, **S. Africa**
18:00 -18:15	Toward Flexible Piezoelectric III-Nitride Nanowire-based Nanogenerators. **N. Buatip**, P. John, T. Auzelle, F. Donatini, S. Le Denmat, B. Fernandez, M. Saluan and R. Songmuang	**Dr. Natthawadi Buatip**, Grenoble Alpes University-CNRS, **France**
18:15 -18:30	Are fractals useful for supercapacitor applications? – A case of Fe2O3 negative electrodes. R. Jaiswal, G. Chaturvedi, V. Sharma, S. A. Ilangovan, S. Sujatha, K.S. Ajeesh and S. **Sarma V. Tatiparti**	**Prof. Sankara Sarma V. Tatiparti**, Indian Institute of Technology Bombay, **India**

Conference Dinner : 19:30 – Verrière

June 06, 2024

Nanotech France / GAMS / Biotech France 2024 Joint Session II.C: Nano for life science and Medicine

Conference Room Derain 1-2

Session's Chairs:
Prof. Ulla Birgitte Vogel, Technical University of Denmark, Denmark
Prof. K Jimmy Hsia, Nanyang Technological University, Singapore
Dr. Andreas Tapia Arellano, Institute for Bioengineering of Catalonia- Barcelona, Spain

14:00 - 14:30	Plasmonics Nanosensors and Nanoprobes: A New Generation of Nanoplatforms for Diagnostics and Treatment of Cancer. **T. Vo-Dinh**	**Prof. Tuan Vo-Dinh**, Duke University, **USA**
14:30 - 15:00	Nanovesicles as Tools to Protect the Skin against Environmental Stressors. **E. Esposito**, M. Sguizzato, F. Ferrara, A. Bondi, W. Pula, M. Benedusi, L. Calderan, M.G. Ortore, M. Malatesta and G. Valacchi	**Prof. Elisabetta Esposito**, University of Ferrara, **Italy**
15:00 - 15:30	Nanoencapsulation: From 1D van der Waals Heterostructures to Cancer Therapy. **G. Tobías-Rossell**	**Dr. Gerard Tobías-Rossell,** Institut de Ciencia de Materials de Barcelona (ICMAB-CSIC), **Spain**
15:30 -15:45	Graphene functionalization towards biodegradability. **S. Rahimi**, M. Bahmani and I. Mijakovic	**Dr. Shadi Rahimi,** Chalmers University of Technology, **Sweden**
15:45 -16:00	Quantification and characterization of manufactured nanomaterials shed from non-medical face mask. R. Mehri, Z. Gajdosechova, T.A. Sipkens, J.C. Corbin, **A. Belknap**, D. Vladisavljevic and G.J. Smallwood	**Mr. Andrew Belknap**, Health Canada- Ottawa, **Canada**
16:00 - 16:30	**Afternoon Coffee Break**	

Session's Chairs:
Prof. Ulla Birgitte Vogel, Technical University of Denmark, Denmark
Dr. Andreas Tapia Arellano, Institute for Bioengineering of Catalonia- Barcelona, Spain

16:30 - 17:00	Is the future of antioxidants mineral? Nanozymes and other nanotechnology solutions. **V. Puntes**	**Prof. Victor Puntes**, Catalan Institute of Nanoscience and Nanotechnology, **Spain**
17:00 - 17:15	Investigating hybrid lipid-PLGA nanoparticles loaded with an endogenous endocannabinoid-like molecule for targeting inflamed muscle. **E. Leo**, S. Molinari, E. Maretti and C. Rustichelli	**Prof. Eliana Leo**, University of Modena and Reggio Emilia, **Italy**
17:15 - 17:30	Pathogen-associated molecular pattern-coated inorganic nanocarriers: a biomimetic approach for subunit vaccines. **L. M. López-Marín**, C. Valdemar, A. Cuán, R. Nava and R. Avila	**Dr. Luz M. Lopez-Marin**, National Autonomous University of Mexico, **Mexico**
17:30 - 17:45	Reprogramming Tumor-Associated Macrophages: Utilizing mU-NO-Conjugated Gold Nanoparticles in Combination with X-ray Irradiation. **Z. Kayani**, S; Iyer and A-C. Heuskin	**Dr. Zahra Kayani**, University of Namur, **Belgium**
17:45 - 18:00	Development of hybrid nanomaterials based on AuNR@MOF/CCMoid to improve the detection of metal ions by fluorescence emission. **C. Araneda**, N. Parra, P. Cabrera, M. J. Kogan and M. Soler	**Mrs. Catherine Araneda**, University of Chile, **Chile.**
18:00 - 18:15	Development of zeolite-based voltammetric sensor for determination of antipsychotic drug quetiapine. **M. Madej**, A. Cader, P. Bandyk, M. Tomaszewska, K. Fendrych, J. Kochana and B. Baś	**Dr. Maria Madej**, Jagiellonian University, **Poland**

Conference Dinner : 19:30 – Verrière

June 07, 2024

NanoMatEn - Session III
Nanotechnology for Environmental Application / Water treatment

Session's Chairs:
Prof. Marco Piumetti, Politecnico di Torino,Italy
Prof. Victor Puntes, Catalan Institute of Nanoscience and Nanotechnology, Spain
Dr. Vinod Paidi, European Synchrotron Radiation Facility- Grenoble, France

Conference Room Derain 1-2

09:00 - 09:30	Sustainable Technologies for Environment. **M. Piumetti**	**Prof. Marco Piumetti,** Politecnico di Torino,**Italy**
09:30 - 10:00	Graphene oxide and noble metal loaded Ca/Ba/SrTiO3 hybrid photocatalysts for environmental remediation. **B. Pal** and M. Passi	**Prof. Bonamali Pal**, Thapar Institute of Engineering and Technology, **India**
10:00 - 10:30	**Morning Coffee Break**	
10:30 - 11:00	Low-Temperature Recovery of Deteriorated Ni-Rich Cathode Material Surfaces: LiNiO2 and LiNi0.8Mn0.1Co0.1O2 Examples. **F-M. Wang**	**Prof. Fu-Ming Wang,** National Taiwan University of Science and Technology, **Taiwan**
11:00 - 11:15	Nature of Al-Mg electrodeposition using chloride-based molten salt electrolyte system. **S. Bhaskaramohan**, M. J. N. V. Prasad, G. V. D. Jonnalagadda, K. Gourishankar, S. Swaminathan, F. Ebrahimi and S. S. V. Tatiparti	**Ms. Sreesvarna Bhaskaramohan**, Indian Institute of Technology Bombay, **India**
11:15 - 11:30	Bio-nanomaterials of polymers and fibrillated nanocellulose: prepara-tion, characterization and removal of emerging pollutants from water. **J. Sanchez**, E. Oyarce, K. Roa, A. Boulett and G. Pizarro	**Prof. Julio Sánchez**, Pontifical Catholic University of Chile, Santiago, **Chile**
11:30 - 11:45	Investigation of PANI-NSA/$NiFe_2O_4$ Nanocomposite for Efficient Removal of Metal Pollutants from An Aqueous Solution. **RN. Kasavo** and HG. Brink	**Ms. Ruth Kasavo,** University of Pretoria, **S. Africa**
11:45 - 12:00	Immobilization of laccase on metal-chitosan nanocomposite and its application in pollutant remediation. **H.D. Kyomuhimbo**, E. M. N. Chirwa, U. Feleni and H. G. Brink	**Ms. Hilda Dinah Kyomuhimbo**, University of Pretoria**, S. Africa**
12:00 - 12:15	Highly Sustainable Polyethylene oxide/sodium alginate-based Electrospun Nanofibrous Superabsorbent Mats as Controlled-release Fertilizer Systems. **P. Chauhan** and B. Kumar Satapathy	**Dr. Pooja Chauhan**, Indian Institute of Technology-Delhi, **India**
12:15 - 12:30	Fluidized bed chemical reactor model for production of syngas in thermo–chemical looping of Ceria. W. Jaroszuk and **J. Milewski**	**Prof. Jaroslaw Milewski**, Warsaw University of Technology, **Poland**

Posters Sessions

June 05 and 06, 2024

N.	Title	Author / Affiliation / Country
1.	Low temperature synthesis of crystalline GaN from a mixture of Li and Ga under N2 atmosphere. **Y. Song**	**Prof. Youting Song**, Institute of Physics, Chinese Academy of Sciences, **China**
2.	Green Route to Copper Nanoparticles on Natural Zeolite Clinoptilolite: Synthesis and Characterization. **M. Lallukka**, F. Gattucci, M. Piumetti and M.Miola	**Ms. Mari Lallukka**, Politecnico di Torino,, **Italy**
3.	Control on the formation of colloidal crystals of uniform populations of cubic maghemite nanoparticles with tunable size and surface chemistry **A. Shahmanesh**, A. Ngo and I. Lisiecki	**Dr. Ashkan Shahmanesh**, Sorbonne University, **France**
4.	Production of biopolymers from pumpkin shell waste and its effect on filtration and rheological properties of water-based drilling mud- to-ward sustainable drilling. **F. Faraji**, S. Baloochzadeh and M. Abdulqadir	**Dr. Foad Faraji**, Teesside University, **UK**
5.	Preparation of high-porosity thin metal films using high-angle ion sputtering and high-fluence high-energy ion bombardment. **G. Ceccio**, J. Vacik, V. Lavrentiev, R. Miksova and P. Pleskunov	**Dr. Giovanni Ceccio**, Nuclear Physics Institute of Czech Academy of Science, **Czech Rep.**
6.	Reversible thermal conductivity switching of Mg-based thin films controlled by hydro-/dehydrogenation reactions. **T. Yagi**, H. Yagi, K. Sugimoto, K. Nakano, Y. Yamashita, T. Shiga, M. Kashiwagi, S. Takeya, Y. Oguchi, F. Iesari, T. Okajima, N. Taketoshi and Y. Shigesato	**Dr. Takashi Yagi**, National Institute of Advanced Industrial Science and Technology, **Japan**
7.	Improvement of Photosensor Properties of ZnO Films by Using the Features of Nanostructured State. S. Dukarov, S. Petrushenko, K. Adach, **M. Fijalkowski**, A Fedonenko and V. Sukhov	**Dr. Mateusz Fijalkowski**, Technical University of Liberec, **Czech Rep.**
8.	Ti/TiSi/TiSiN/TiSiCN protective multilayered structures used for industrial woodworking applications obtained by cathodic arc evaporation. **L. R. Constantin**, A. C.Parau, M. Dinu, I. Pana, C. Vitelaru, D.M. Vranceanu and A. Vladescu	**Dr. Lidia R. Constantin**, National Institute of Research and Development for Optoelectronics - INOE 2000, **Romania**
9.	Radial lower chuck design using metamaterials and prediction of sur-face roughness in PBF. **K. W. Kim**, J. W. Lee, S. H. Park, S. Y. Lee, S. Y. Gu, D. H. Kim and J. H. Sung	**Dr. Kunwoo Kim**, Korea Institute of Industrial Technology- Daegu, **Rep. of Korea**
10.	New route to synthesis nanomaterial of lead sulfide (galena) films from bis(alkylxanthato) lead(II) precursors. **Y.T Alharbi** and D. Lewis	**Dr. Yasser Alharbi**, Yanbu Industrial College, **Saudi Arabia**
11.	Electrospun Polycaprolactone Nanofibers: Influence of Fiber Diame-ter on Bacterial Biofilm Formation and Bacterial Cell Retention. **S. Lencova**, M. Stindlova, V. Peroutka, V. Jencova, K. Havlickova, D. Lukas and K. Demnerova	**Dr. Simona Lencova**, University of Chemistry and Technology- Prague, **Czech Rep.**
12.	Antibacterial Activity of Electrospun Fibers with Graphene. **V. Peroutka**, S. Lencova, C. G. Aneziris, E. Storti, K. Demnerova and O. Jankovsky	**Mr. Václav Peroutka**, University of Chemistry and Technology- Prague, **Czech Rep.**
13.	Effect of nanofibrous materials with different morphology on bacterial and yeast biofilm formation. **M. Stindlova**, S. Lencova, K. Zdenkova, V. Jencova, E. Kuzelova Kostakova, S. Hauzerova, D. Lukas and K. Demnerova	**Mrs. Marta Stindlova**, University of Chemistry and Technology- Prague, **Czech Rep.**
14.	Bacterial biofilm degradation measurement using biophysical parameters. **K. Gałczyńska**, A. Węgierek-Ciuk, S. Wąsik, M. Baczewska, A. Kuś, M. Kujawińska and M. Arabski	**Dr. Katarzyna Gałczyńska**, Jan Kochanowski University, **Poland**
15.	The cytotoxic effect of ruthenium and copper dendrimers on eukaryotic cells measured by holographic method. **A. Węgierek-Ciuk**, K. Gałczyńska, M. Baczewska, A. Kuś, P. Ortega, F.J. de La Mata, M. Kujawińska and M. Arabski	**Dr. Aneta Węgierek-Ciuk**, Jan Kochanowski University, **Poland**

16.	Novel materials containing Lipoic acid and metal oxide nano particles for Hydrogel Contact Lens. C-Y. Kim, S-Y. Park and **A-Young Sung**	**Prof. A-Young Sung**, Daegu Catholic University, **Rep. of Korea**
17.	Preparation, chemical – physical characterization of composite hydrogels – nanoparticles of Ag and Ag2MoO4. Stability analysis and biomedical applications. **S. Calistri**, A. Ubaldini, A. Rizzo and C. M. Cellamare	**Ms. Sara Calistri**, University of Bologna, **Italy**
18.	pH-sensitive polymer nanoparticles preparation - a nanoplatform for 5-fluorouracil delivery. I. Ivanova, T. Popova, M. Slavkova, B. Tzankov and **C. Voycheva**	**Dr. Christina Voycheva**, Medical University of Sofia, **Bulgaria**
19.	Investigation of the effects of the preparation method on the properties of nanostructured lipid carriers. M. Slavkova, C. Voycheva, T. Popova and B. Tzankov	**Dr. Marta Slavkova**, Medical University of Sofia, **Bulgaria**
20.	Non-carboxylated and Carboxylated Mesoporous Carbon Nanoparticles Loaded with Bicalutamide – an Advanced Nanosystem for Combined Chemo-photothermal Therapy. **T. Popova**, B. Tzankov, M. Slavkova, Y. Yordanov, V. Georgieva, D. Stefavova, V. Tzankova, D. Tzankova, Iv. Spasova, D. Kovacheva and Ch. Voycheva	**Dr. Teodora Popova**, Medical University of Sofia, **Bulgaria**
21.	Development of Innovative Drug Delivery System for Optimized Therapy of Traumatic Skin Conditions. **B. Tzankov**, T. Popova, Iv. Spasova, D. Kovacheva, Ch. Voycheva and M. Slavkova	**Dr. Borislav Tzankov**, Medical University of Sofia, **Bulgaria**
22.	Design of new nano-tools to target mitochondria and study the metabolic plasticity of cancer cells. D. Akbarzadeh, J.C. Calderón de la Rosa, J. Spadavecchia, M-O. David, F. Treussart, N. Modjtahedi and **G. Urbinati**	**Dr. Giorgia Urbinati**, CNRS/ Gustave Roussy Cancer Campus, **France**
23.	Role of Nanoparticle-Based Drug Delivery Systems Pharmaceutical Properties into Shaping the Risk-Benefit Ratio of Investigational Medicinal Products in Clinical Studies for Cancer Treatment. **H. Abdel-Haq**	**Dr Hanin Abdel-Haq**, Istituto Superiore di Sanità- Rome, **Italy**
24.	DNA nanotechnology to fight infectious diseases. **M. Cambra-Pellejà**, Q. Yang, L. Baptista-Pires, M. Vilaplana, J. Muñoz, J. Gandasegui and C. Parolo	**Ms. Maria Cambra**, Barcelona Institute for Global Health- Barcelona, **Spain**
25.	Microfluidics based homogenous size chlamydial nanovaccine poten-tiates immune responses. **V.A. Dennis**, R. Sahu and L. Gildea	**Dr. Vida A. Dennis**, Alabama State University, **USA**
26.	Risk Assessment of Nanomaterials and Development of GIS-Based Decision Support System for Environmental and Human Health Protection. S. J. Son, J. H. Kim, **J. W. Kim**, S. H. Yoo and Y. H. Cho	**Ms. Jinwon Kim**, Sundosoft Co., Ltd.- Seoul, **Rep. of Korea**
27.	Enhanced Stability and Reusability for Purifying Therapeutic Anti-bodies a Ca2+ -responsive Fusion Protein Development. **H. Park** and S. Kim	**Ms. Heesun Park**, Korea Institute of Ceramic Engineering and Technology- Cheongju, **Rep. of Korea**
28.	Effect of Barcopa monnieri extract on autophagy and apoptosis in lung cancer A549 cell. W. Poorahong, S. Innajak, P. Sitthisuk, E. Tashiro, M. Imoto and **R. Watanapokasin**	**Prof. Ramida Watanapokasin**, Srinkharinwirot University, **Thailand**
29.	Viability and cell migration of chitosan-pluronic F127 and reduced graphene oxide hydrogels as wound healing dressings. **I. Ruíz**, K. Frnández and C. Aguayo	**Mrs. Isleidy Ruiz**, University of Concepcion, **Chile**
30.	Valorization of grape pomace by obtaining some functional ingredents with antioxidant and antimicrobial activities. **E.I. Geană**, C.T. Ciucure, R. Tamaian, I.C. Marinaș, M.S. Stan and R.E. Ionete	**Dr. Elisabeta-Irina Geana**, National Research and Development Institute for Cryogenics and Isotopic Technologies, **Romania**
31.	Identification of microorganisms involved in leather biodegradation and heavy metal resistance. **M. Bonilla-Espadas**, B. Zafrilla, I. Lifante-Martinez, M. Camacho, E. Orgi-lés-Calpena, F. Arán-Aís, M. Bertazzo and M-J. Bonete	**Ms. Manuela Bonilla Espadas**, INESCOP. Footwear Technological Centre, **Spain**

32.	Willis coupling in elastic torsional waves. **Y. Hao**	**Dr. Yiran Hao,** National University of Defense Technology, **China**
33.	Electrosynthesis of nanostructured Bio-based thin films for improved photoactivation of peroxymonosulfate for water decontamination. **A. Serrà**, L. Huidobro, Q. Bautista and E. Gómez	**Dr. Albert Serrà**, University of Barcelona, **Spain**
34.	Air humidity as a new source of green energy. L. Fernandez Velasco, A. Bessegmar Carrera, **P. Melo Bravo**, S. Lyubchyk, A. Lyubchyk and S. Lyubchyk	**Mrs. Paulina Melo Bravo**, Royal Military Academy- Brussels, **Belgium**
35.	Use of alumina nanoparticles to mitigate solid particle impact erosion in polymeric composite material for leading edge of wind turbines. **L E Ramirez Peña**, C Mejía-García, A M Paniagua-Mercado, M Tufiño Velazquez, A S De Ita-De la Torre.	**Mr. Luis Esteban Ramirez Peña**, Instituto Politécnico Nacional, **Mexico**
36.	Synthesis of Au Nanoparticles by Green Method Using Jacaranda Flowers. C. Mejía García, G. Jaimez Layna, **L.E. Ramirez Peña**, E. Díaz Valdés, G.S. Contreras Puente, Á. Guillen Cervantes and M. de Lourdes R. Morales.	**Mr. Luis Esteban Ramirez Peña**, Instituto Politécnico Nacional, **Mexico**
37.	Plant Nanofactory: Toward green synthesis of inorganic nanoparticles. **Y. Aman**	**Dr. Yann Aman**, University Félix Houphouet Boigny, **Ivory Coast**
38.	Sacrificial 3D Printing to Fabricate MXene-Based Wearable Sensors with Tunable Performance. **A. Osman**, H. Liu and J. Lu	**Mr. Amr Osman**, City University of Hong Kong, **China**

Nanotech France / GAMS/ Biotech France 2024 Joint Plenary session

Epitaxial Growth of Silicene : Successes and Challenges

L. Masson
CINAM, CNRS, Aix-Marseille University, Marseille, France

Abstract:

Since the breakthrough of graphene, two-dimensional (2D) materials have become a major field in material research, largely motivated by their outstanding electronic and optical properties that foresee their integration into a wide range of next-generation devices. In this context, 2D materials composed of post-carbon group 14 atoms, in particular silicon and germanium, have attracted a great deal of interest over the last fifteen years due to their valence electronic configuration similar to that of graphene and their widespread use in the semiconductor industry. Indeed, the electronic properties of silicene and germanene are expected to be easier to tune than those of graphene. Silicene, the silicon counterpart of graphene, has been particularly studied, both theoretically and experimentally. Theoretical studies first predicted a low-buckled honeycomb structure for free-standing silicene possessing most of the electronic properties of graphene [1]. From an experimental point of view, a key issue in exploiting the potential of silicene lies in its synthesis. Since no layered structure analogous to graphite exists for silicon, silicene cannot be obtained by exfoliation of the bulk material as with graphene and a substrate that generally dictates the monolayer structure is necessarily required for the epitaxial growth of 2D Si layers [2]. A state-of-the-art review on the different strategies developed to synthesize low-buckled Si honeycomb structures by epitaxial growth will be presented, with a focus on silver substrates, the most frequently substrates that have been used so far (Figure 1). The question of whether epitaxial silicene retains the peculiar electronic properties of free-standing silicene will be addressed. Finally, with a view to applications, the reactivity and air-stability of silicene as well as the strategy devised to decouple epitaxial silicene from the underlying surface and its transfer to a target substrate will be discussed.

Keywords: 2D materials, silicene, graphene, epitaxial growth, honeycomb structure, electronic band structure, scanning tunneling microscopy, surface X-ray diffraction, angle-resolved photoelectron spectroscopy, silicene based electronic devices.

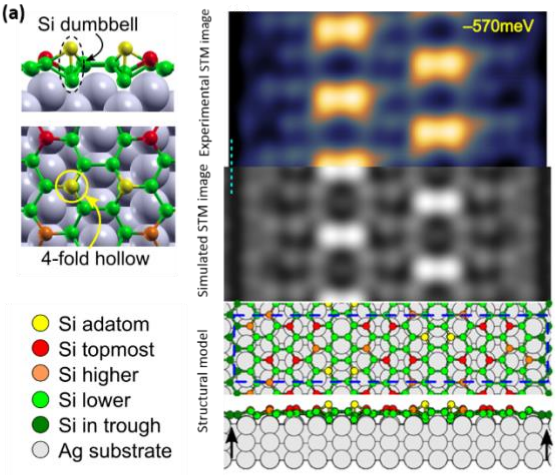

Figure 1: (a) Local adatom geometry showing dumbbell pair formation on a 2D silicene layer. (b) Experimental (blue-yellow colormap, top) and simulated (greyscale, center) STM images and the corresponding structural model of dumbbell silicene (bottom). [2]

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Micro- and Nanorobots: From single agents to microelectronic morphogenesis

Oliver G. Schmidt
Research Center for Materials, Architectures and Integration of Nanomembranes (MAIN),
Chemnitz University of Technology, Germany
oliver.schmidt@main.tu-chemnitz.de

Abstract:
This talk addresses some of the key challenges in the field of micro- and nanorobotics [1]. For instance, by controlling the robots' materials elasticity with nanscale precision by confocal photolithographic manufacturing of a novel magnetically active material, cell-sized picoforce springs with remarkably large and tuneable compliancy can be fabricated – allowing articulated motion in microrobots as well as micromanipulations and force sensing well beyond state of the art [2]. The storage and delivery of energy for truly autonomous operation of microrobotic systems represents another key challenge in the field [3] and will be addressed by producing world's tiniest on-board integrated batteries and biosupercapacitors [4,5]. The ability to create compact microelectronic robots leads us to the concept of microelectronic morphogenesis (MIMO) [6]. MIMO is the creation of form and structure under microelectronic control, and relies on our previous work on self-folding [7] and self-locomoting [8] thin film electronic modules, now carrying tiny silicon chiplets between the folds, for a massive increase in information processing capabilities.

Keywords: microrobotics, nanorobotics, microelectronics, system integration, morphogenesis, soft materials, micro-origami, self-assembly, artificial life, living technologies, artificial organisms

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The sythesis of bio-based nanocomposites by an in-situ processing and consolidation method

Rina Tannenbaum
Department of Materials Science and Chemical Engineering, Stony Brook University, Stony Brook, New York 11794, USA

Abstract:

Nanocomposites from renewable resources constitute the new frontier in the development of novel materials that are cheap, versatile and environmentally benign.

Nanocomposites based on renewable and biocompatible filler and matrix materials may find specific applications in technologically important areas such as surgical implants, tissue engineering scaffolds, structural materials, coatings and energy harvesting. A particularly promising class of renewable resource nanoparticles that exhibit superior mechanical strength and encompass a wealth of surface reactivity and biocompatibility are cellulose nanocrystals. Cellulose nanocrystals (CNC), which constitute the reinforcing element in cellulose microfibrils, can be extracted and used as reinforcement in high strength polymer-based nanocomposites. The modulus and strength of such reinforced composites compare favorably with composites reinforced with glass and aramid fibers, aluminum, and magnesium alloy. This, in conjunction with a strong hydrogen bonding ability, enables cellulose whiskers to attain a percolation threshold of as low as 1 wt.%. However, the strong hydrogen bonding interactions between cellulose molecules tends to make homogeneous dispersion of cellulose fibers difficult, especially in a non-polar matrix. Dispersion of cellulose fibers through melt processing is not an option because decomposition of the polymer occurs prior to melting. To date, good dispersion of cellulose microfibrils has been achieved only by the "dispersions mixing" method, which involves mixing a homogenized suspension of microfibrils with a latex suspension of the matrix polymer. This processing technique allows an intimate mixture of cellulose and matrix, enabling processing of high strength composite films. However, consolidation of the composite (film) requires volatilization and removal of the solvent phase, which inevitably create defects (e.g. voids) in the final product.

Keywords: Biocomposites, material sustainability, biocompatibility, carbon neutrality, matrix-filler interfaces, nanocomposite processing, acid based polymerization, tissue scaffolds.

This talk will describe the synthesis and characterization of the cellulose nanocrystals and the formation of nanocomposites by the in-situ consolidation of reactive solvent components. This will include the use of reactive monomers, such furfuryl alcohol, that can be polymerized at ~60°C, or the use of bio-based epoxy-type systems, such as cardanol-based epoxidized novolac vinyl ester resins, that can be generated at ~90°C. A schematic illustration of this process is shown in Figure 1.

We will explore the basic biocompatibility characteristics of the new bio-based nanocomposites, such as their long-term inflammatory and thrombogenic potential, in order to ascertain their suitability for integration into various biological applications. These studies were achieved through our customized tissue simulation studies, which make use of physiologically relevant microenvironments to test short-term and long-term tissue responses. Biological performance testing were performed in parallel with the synthesis, development and characterization techniques, providing an immediate and important feedback loop regarding appropriate design of and applications for our new bio-based nanocomposites.

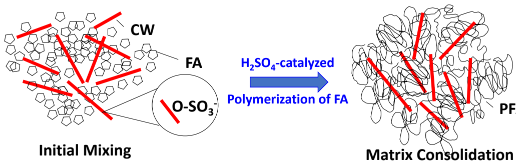

Figure 1: Schematics of the in-situ acid-catalyzed polymerization of FA with well-dispersed CNC fillers.

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Nanotech France / GAMS 2024 Joint Session I.A: Nanomaterials Fabrication / Synthesis / properties

Solution Combustion Synthesis of Nanomaterials: Recent Advances

A.S. Mukasyan
Department of Chemical and Biomolecular Engineering, University of Notre Dame,
Notre Dame, 46556, Indiana, USA

Abstract:

Solution combustion synthesis (SCS) is a green, energy-saving approach that allows for an easy scale-up and continuous technologies[1]. SCS contains non-catalytic self-sustained exothermic reactions along an aqueous or sol−gel media. The reactive solutions contain oxidizers and fuels dissolved in a solvent. The reaction in such a solution can be initiated in two different regimes. Volume combustion synthesis (VCS) implies preheating the whole solution to the self-ignition temperature (T_{ig}). After reaching T_{ig}, the reaction begins uniformly along the whole volume of the reactive media, resulting in the formation of the desired solid product. The self-propagating high-temperature synthesis (SHS) regime involves local preheating of the solution to initiate the reaction, followed by the combustion wave propagating along the reactive media, leading to the formation of the solid product. In both cases, no external heat sources are required for reaction occurrence after initiation, because a lot of energy is released due to exothermic chemical reactions. Each of these modes has unique features and can be applied to fabricate various nanomaterials, including oxides, metals, alloys, nitrides, and carbides, with high specific surface areas and narrow size distributions. By adjusting the composition of the reactive solution, fuel type, and combustion regimes, researchers can fine-tune the properties of the materials produced for different applications[2,3].

In this review we critically analyzes the recent advances on the SCS of materials. To better understand the principles of SCS, its driving parameters, and their role in synthesis process, we will briefly summarize the fundamentals of the method. We also outline challenges and suggest specific directions of research that will allow the improvement of the characteristics of such materials.

Keywords: self-sustained reactions, combustion synthesis, nanomaterials, biomedical application, supercapacitors, catalysis

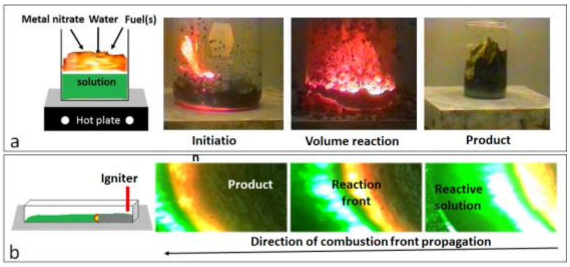

Figure 1: Figure illustrating different SCS regimes: (a) the volume combustion synthesis mode: initial solution installed on the hot plate; reaction initiation stage; volume combustion synthesis stage; final product; (b) the self-propagating combustion synthesis mode: reaction propagates from right to left with constant velocity of the combustion front.

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Novel Cyclodextrin-Based Supramolecular Polymers for Nanomedicine and Environmental Sustainability Applications

Jun Li [1,2,*]
[1] Department of Biomedical Engineering, National University of Singapore, Singapore
[2] NUS Environmental Research Institute (NERI), National University of Singapore, Singapore

Abstract:

Supramolecular host–guest chemistry based on cyclodextrins and guest molecules has offered a powerful and convenient approach for fabricating complicated nanostructures self-assembled from individually tunable molecular building blocks. Over the past 20 years, our research group has been working on developing novel supramolecular self-assembled polymeric micro- and nanostructures starting from biobased and synthetic polymers as building blocks. The polymer blocks were designed to form self-assembled structures, such as stimuli-responsive hydrogels, micelles, nanovesicles, micro- and nanoparticles and capsules, and surface coatings. These structures have been explored as advanced materials for applications in two important areas: biomedicine and environmental sustainability.

For example, incorporating multiple functional features into a single drug and gene carrier system to overcome numerous hurdles during the delivery of drugs and genes has been challenging. Usually, controlling the molecular architecture and composition of a multifunctional carrier system for optimizing delivery efficiency requires multistep chemical synthesis and conjugation processes. Herein, we demonstrate a supramolecular approach for building multifunctional carrier systems with controllable molecular architectures based on the host-guest chemistry of cyclodextrins. A system has been developed based on rationally designed host-guest complexation between a β-cyclodextrin-based cationic host polymer and a library of guest polymers with various PEG shapes and sizes and various ligand densities (Figure 1). The host polymer is responsible for condensing and loading/unloading siRNA, while the guest polymer is responsible for shielding vehicles from nonspecific cellular uptake, prolonging circulation time, and actively targeting tumor cells.[1] A series of siRNA vehicles with precisely controlled molecular architectures generated through a simple assembly process allows for rapid optimization of siRNA delivery vehicles in vitro and in vivo for efficient targeted delivery of therapeutic siRNA-Bcl2 for tumor therapy. The good correlation between in vitro and in vivo data indicates that this approach is a useful screening tool for identifying targeted gene delivery vehicles.

In addition, we will introduce our works on supramolecular polymers for environmental applications.[2]

Keywords: cyclodextrin, supramolecular polymer, hydrogel, biomaterials, drug delivery, gene delivery, absorbent, water treatment, environmental application.

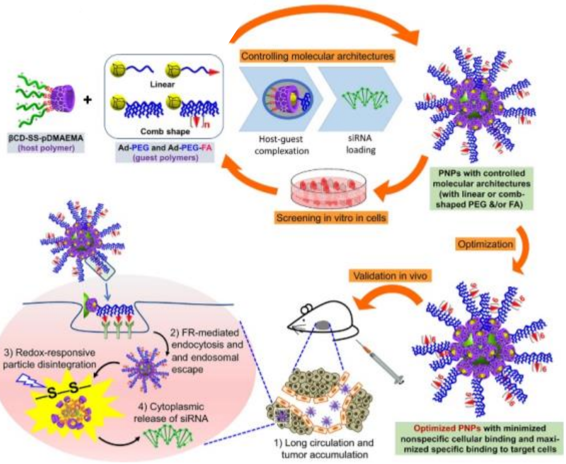

Figure 1: Supramolecular screening system for optimized gene delivery developed based on rationally designed host-guest complexation between a β-cyclodextrin-based cationic host polymer and a library of guest polymers with various PEG shapes and sizes and various ligand densities

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Synthesis of Ultra-Small Gold Nanostars for Applications in Catalysis, Sensing and Photothermia

E.S. Abu Serea[1], L.B. Berganza[1], S. Lanceros-Méndez[1,2], and J. Reguera[1]*
[1] BCMaterials, Basque Center for Materials, Applications, and Nanostructures, UPV/EHU Science Park, Leioa 48940, Spain
[2] Ikerbasque, Basque Foundation for Science Bilbao, 48009 Bilbao, Spain

Abstract:

Currently, gold nanostars (NSs) are becoming increasingly attractive as the main enablers of a wide set of advanced applications, ranging from biomedicine to sensing or catalysis.[1] Their anisotropic structure and their sharp tips that grow from the central core offer enhanced optical capabilities and tunability from the visible to the near IR (NIR). Several synthesis methods have been reported, that generate NSs of different morphologies with nanostar's tips varying in number, length, symmetry, and thickness, and with a wide range of sizes that can extend to several hundreds of nanometers.[2] However, obtaining small NSs, while maintaining their plasmonic properties at the NIR, has proven challenging. Here, we show that the addition of Cu^{2+} during the synthesis of Au NSs in DMF/PVP generates a higher amount of crystalline defects giving rise to nanostars with a larger number of thinner tips and the formation of tips at earlier growth times. This last property makes possible the generation of ultra-small NSs (USNSs), with a volume as small as 1663 nm^3, i.e. 14.7 nm equivalent diameter, while maintaining a localized surface plasmon resonance into the NIR, highly desirable for many applications. To this end, here we systematically evaluated the influence of synthesis parameters on the NS size and optical characteristics and demonstrated their properties for application on catalytic reduction, plasmonic hyperthermia, SERS sensing, and formation of ultra-small Janus plasmonic magnetic nanoparticles (Figure 1). The USNSs showed excellent characteristics in all of them while offering a small size which can enhance properties related to the higher surface-to-volume ratio or colloidal diffusivity.[3]

Keywords: gold nanostars, hyperthermia, catalysis, SER

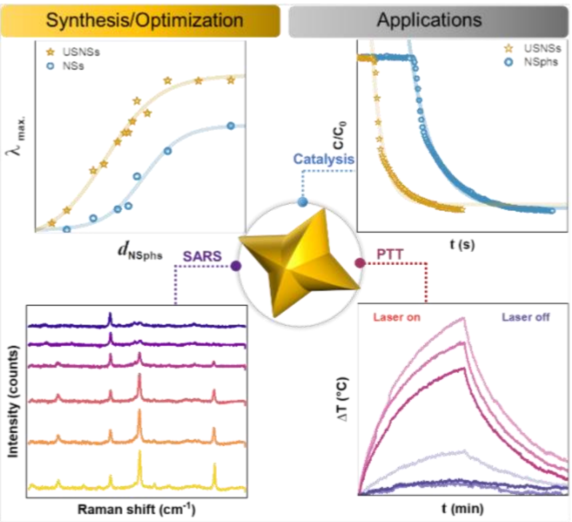

Figure 1: A systematic evaluation of synthesis parameters and the addition of Cu^{2+} allowed to determine their impact on nanostar (NS) size and optical properties, yielding NSs with unprecedented small size, here called ultra-small gold nanostars (USNSs). Their small size has enormous advantages in applications including catalysis, sensing, and biomedicine.

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Preparation and characterization of different type of aligned Cellulose nanofiber

F. Mohtaram [1], P. Fojan [1]
[1] Material and Production Department, Aalborg University, Aalborg, Denmark

Abstract:
Nanocellulose includes cellulose nanocrystals (CNCs), cellulose nanofibrils (CNFs), and cellulose nanofibers (CNF), which are extracted from native cellulose through mechanical or chemical treatments. Nanocellulose exhibits exceptional mechanical strength, biocompatibility, and biodegradability, making it a promising material for various applications, including nanocomposites, biomedical devices, and functional coatings.

In this study, three types of cellulose (long, medium, and cellulose acetate (CA)) with different concentrations were used to produce cellulose nanofibers by means of electrospinning. For the direct dissolution of cellulose, we used three different solvent systems: (a) a solution of 60/40 trifluoroacetic acid in dimethylacetamide (TFA/DCM), (b) a TFA free solution composed of NaOH7Urea/PVA, and (c) an acetone solution in the case of CA.

Highly aligned cellulose nanofibers were successfully prepared via electrospinning. Their directional alignment can enhance mechanical strength of the produced mats, electrical conductivity, and transport properties, making them suitable for applications that require controlled structural and functional properties. Figure 1 shows the nanofiber alignment of cellulose with long fibrils. The produced fibers were characterized with scanning electron microscopy (SEM), X-ray diffraction (XRD), Raman spectroscopy, and thermal gravimetric analysis. The cellulose nanofiber prepared from a 4 (w/v)% solution from cellulose with long fibrils exhibited desirable properties such ashigh crystallinity and thermal stability

Keywords: Cellulose; nanofiber; electrospinning method; aligned nanofiber

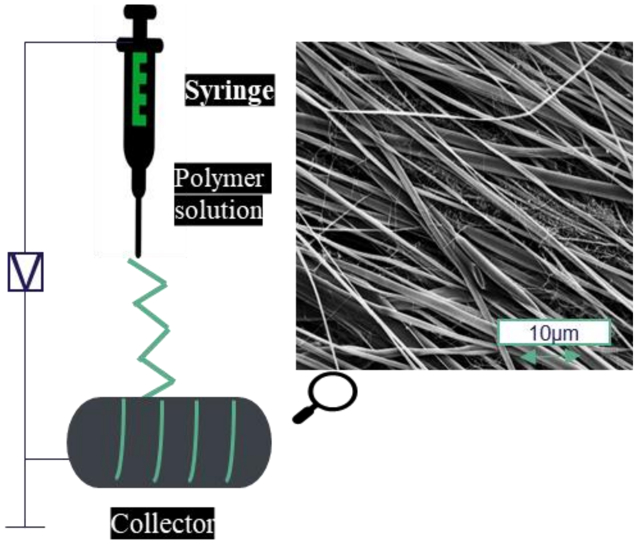

Figure 1: Highly oriented nanobfibers of 4 (w/v)% cellulose with long fibrils. with constant spinning parameters: feed rate(1ml/min), voltage(18kv), Needle to collector distance (19cm) and the drum roration speed (800rpm)..

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Synthesis and Self-Assembly of Titania Nanoplatelets and Their Encapsulation in a Polystyrene Shell *via* Photocatalytic Surface-Grafted Radical Polymerization

J. Struck [1,*], B. Sochor [2], T. Vossmeyer [1]
[1] Physical Chemistry Department, University of Hamburg, Hamburg, Germany
[2] Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Abstract:

Natural composite materials such as nacre have gained significant interest due to their exceptional mechanical properties including high hardness and toughness.[1] Very promising bio-inspired materials are inorganic nanoplatelets stabilized by a soft layer of organic ligands. Such nanoplatelets can self-assemble into hierarchically ordered superlattice structures, resembling the architecture of tough biocomposites. Here, we explore the synthesis of titania nanoplatelets (TNPs), their self-assembly into supraparticles *via* emulsion-based methods and subsequent encapsulation within a polymer shell.

The oleyl amine stabilized TNPs (Figure 1A) are synthesized *via* an adapted seeded-growth approach[2] and can be assembled into supraparticles *via* emulsion induced self-assembly.[3] This process yields 3D supraparticles with sizes of approximately 100 – 400 nm (Figure 1B). Subsequent encapsulation within a polymer shell is expected to enhance the mechanical properties of these supraparticles. We developed a novel photocatalytic surface-grafted radical polymerization exploiting the inherent photocatalytic activity of the TNPs. By varying the UV light exposure time one can easily tune the polymer shell thickness (Figure 1C). An interesting finding is the high degree of order of the TNPs within the encapsulated supraparticles which was confirmed *via* synchrotron small angle x-ray scattering. Most likely, the double bond of the oleyl amine ligands on the nanoparticle surface initiates the polymerization reaction and enables surface-grafting of the growing polymer chains.[4] We are currently expanding this method to the assembly and encapsulation of supraparticles from differently shaped titania nanoparticles (nanorods, nanodots). Further, in order to form a higher-level hierarchically ordered material, we intend to cross-link the supraparticles. To this end, we are exploring the surface-modification of the polystyrene shell with different functional groups. This can be done by adding styrene-based functional monomers for the polymerization reaction. We expect that the encapsulated supraparticles and their higher-level assemblies provide new insights into various properties of hierarchically ordered artificial nanocomposites.

Keywords: titanium dioxide nanoplatelets, self-assembly, photocatalytic polymerization, encapsulation, bioinspiration.

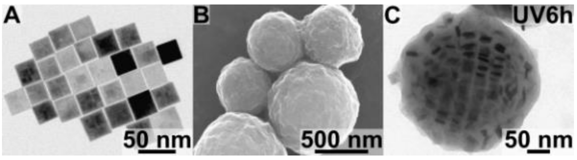

Figure. 1. A) Transmission electron microscopy (TEM) image of synthesized titania nanoplatelets, B) Scanning electron microscopy image of self-assembled supraparticles, C) TEM image of an encapsulated supraparticle exposed to UV light for 6 hours.

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Automated dry synthesis and deposition of nanomaterials

Vincent Mazzola, Tobias Pfeiffer, Aaike van Vugt
VS Particle (Delft, the Netherlands)

Abstract:
State-of-the-art techniques in materials research have drastically expanded the ability to create more advanced materials. Interestingly, the most significant leaps forward in material advancement directly result from our ability to produce and manipulate materials at the smallest scale: the nanoscale. Breaking bulk materials into nanoparticles (NPs) enables new possibilities to change material properties due to quantum mechanics. When it comes to NPs synthesis, conventional wet chemistry techniques are recipe-based and involve multiple steps for the production of NPs and layers. Iterations for conventional synthesis alone usually take many years, besides the wet chemistry steps hamper integration into “automated labs”. An alternative approach to the former cumbersome methods is a single-step, dry synthesis and deposition of NPs via our novel method based on Spark ablation technology. Herein, NPs can be produced from any (semi)conductive material and their combinations, including their alloys within a gas phase without requiring additives or precursors, binders, reagents – often employed by the ink-preparation steps. Subsequently, the produced NPs can be directly deposited onto any substrate by using inertial impaction through an automated and single-step process. The tool for this process has been commercialized by VSParticle as the “Nanoprinter". With this tool, high-purity, nanoporous layers with unique properties can be created using particles smaller than 20 nm as building blocks. Through a user-friendly interface, the system enables precise control of material and process parameters, such as material composition, particle size distribution and layer thickness. Deposition patterns can be specified via a high-level Python interface, which is readily expanded to a wide variety of raster- and vector-based formats. In this presentation, we will disclose the successful implementation of the technology for the fabrication and testing of electrocatalysts for green hydrogen, for sensing material, as well as various other (semi-)conducting material applications (SERS, Nanotoxicology, and others). Through this scalable and versatile dry manufacturing process and the possibility for fast iterations in tuning material parameters, the development and time to market for materials innovation can be accelerated by 5 to 10 times.

Keywords: Nanomaterials, NPs, (Semi)conductors, Sensing, Electrocatalysis, Medical applications, Spark Ablation, Porous layers

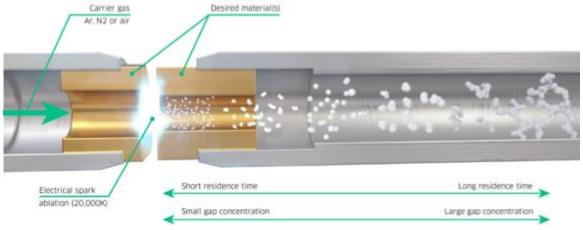

Figure 1: Figure illustrating the Spark ablation mechanism for the synthesis of (semi) conductive nano particles

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Highly Magnified Dimer Sputtering and Nanoparticle Generation via Pulsed Magnetron Discharge

Pavel Curda[1,*], Rainer Hippler[2,3], Martin Cada[2], Ondřej Kylián[4], Zdenek Hubicka[2], Vitezslav Stranak[1]

[1] Faculty of Science, University of South Bohemia, Ceske Budejovice, Czech Republic
[2] Institute of Physics, Czech Academy of Sciences, Prague, Czech Republic
[3]University of Greifswald, Greifswald, Germany
[4]Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

Abstract:

This investigation delves into the early-stage dynamics of nanoparticle formation in physical vapor deposition processes, focusing on the pivotal role of atomic dimers as cluster nuclei. The process of metal nanoparticle nucleation and growth via gas aggregation initiates with the release of metal atoms and nuclei through magnetron sputtering, followed by thermalizing collisions and subsequent atom attachment and coagulation. Employing energy-resolved mass spectrometry and scanning electron microscopy imaging, we examined dimers originating from the discharge gas phase ($ArCu^+$, Ar_2^+) and those sputtered directly from the target (Cu_2^+). Our findings highlight the crucial role of sputtered Cu_2^+ dimers, which exhibit a high-energy tail consistent with the Thompson distribution, as primary nanoparticle formation species. Haberland's aggregation source confirmed correlation between the abundance of Cu2+ dimers and the mass flux of nanoparticles. Optimization of the gas aggregation process for enhanced nanoparticle production involves the utilization of pulsed discharge, resulting in enhanced energies of impinging Ar ions and intensified sputtering of metal dimers. Under optimal conditions, characterized by increased dimer production while maintaining plasma temperatures conducive to nucleation and growth, the nanoparticle production rate can increase by an order of magnitude. This surge in nanoparticle yield is achieved with equivalent power input compared to DC sputtering. Furthermore, our observations suggest the proposed mechanism and the significance of dimers may transcend material specificity, as qualitative agreement was also noted for Ag nanoparticles. This investigation significantly advances our understanding of the underlying physics governing the nascent stages of nanoparticle synthesis via physical vapor deposition.

Keywords: dimer, nanoparticle, gas aggregation nucleation, pulsed magnetron sputtering, energy-resolved mass spectrometry

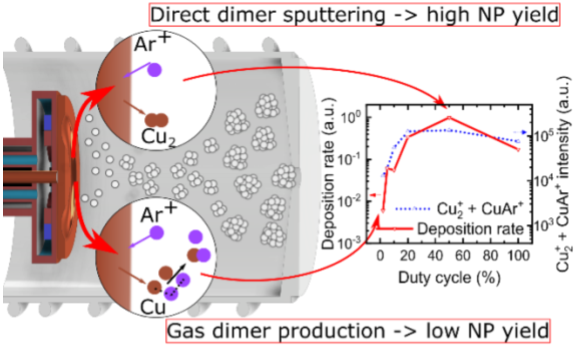

Figure 1: The high production of nanoparticles in gas aggregation cluster source depends on the production of directly sputtered metal dimers.

Acknowledgement:

The research was financially supported by the Czech Science Foundation through the project GACR 21-05030K and by the Ministry of Education, Youth and Sports of the Czech Republic through the project "Solid state physics for the 21st century" CZ.02.1.01/0.0/0.0/16_019/0000760.

Sinter- and Binder-based processing of Mg-alloy AZ41 by MIM (Metal Injection Moulding) reinforced by AlN-nanoparticles

M. Wolff [1], T. Ebel [1], R. Willumeit-Römer [2]
[1] Institute of Metallic Biomaterials, Helmholtz-Zentrum Hereon, Geesthacht, Germany
[2] Christion Albrechts University CAU, Kiel, Germany

Abstract:

Mg-alloys are highly suitable for ultra light wight aerospace and consumer applications and recently also recommended as biodegradable biomaterials [1, 2]. MIM, an economic near net shape mass production technique for high numbers of parts and additive manufacturing, a prototyping technique of individual parts are sinter- and binder-based processing technologies [3, 4]. Since several years Mg-alloy AZ41 could be processed successfully by MIM and additive manufacturing, obtaining an ultimate tensile strength (UTS) of up to 250 MPa [5]. However, the sintering heat treatment close to melting temperature for several hours results in fully stress-relieved microstructure and coarsening up to average particle size d_{50}. Hence, early plastic deformation (e.g. twinning) occurs parallel to elastic deformation at low forces. Therefore the 0.2% plastic deformation limit (yield strength) of sintered Mg-alloys generally achieve moderate limits. To overcome this challenge this study focusses on AlN additions of 40nm in size, applying 0.1wt% and 1wt% of AlN nanoparticles into the magnesium AZ41-powder. For the MIM-processing, a feedstock containing 64vol.% powder loading was prepared. The corresponding 36vol.% bindersystem consist of 35wt% PEcoPP, 60wt% paraffin wax and 5wt% stearic acid. After injection molding of dogbone shape tensile test specimen, solvent debinding of the waxy components took place in hexane at 45 °C for 15 h (Lömi EBA50/2006, Germany), afterwards thermal debinding and sintering took place in a hot wall sintering furnace with separate binder precipitation zone at 618 °C for 16 h (RRO350-900, MUT Advanced Heating, Jena, Germany).

As a result, a significant increasement of the yield strength (YS) of the 1wt% AlN containing AZ41-alloy (YS: 100 MPa±2.6) could be achieved in comparison the the AlN-free reference material (YS: 91.7MPa±0.7). To conclude, the addition of 1wt% AlN nanoparticle just by blending delivers a significant increasment of YS by 9%. Moreover, more effective techniques as there are mechanical alloying of AZ41 powders with AlN nanoparticles will be discussed, too. This study aims at later translation to biodegradable MgGdCa-alloys for biomedical applications as well as processing by sinter based additive manufacturing.

Keywords: Mg, magnesium, AZ41, MIM, sinter based, binder based, 3D, AlN, nanocomposite, biomaterials, biomedical applications, additive manufacturing.

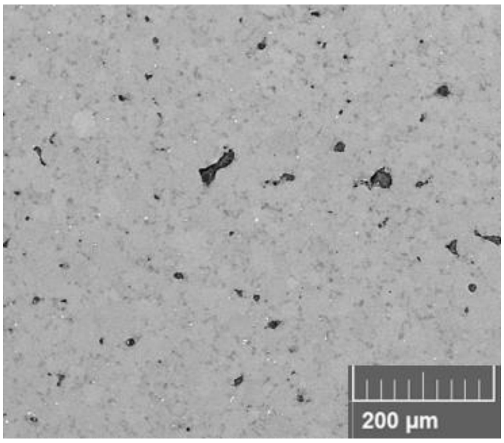

Figure 1: SEM-image of the typical microstructure of sintered Mg-alloy AZ41 reference material without AlN additions showing typical residual porosity of sintered MIM material

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Self-Assembly Approach for the Fabrication of Multi-Level Bio-Inspired Magnetic Nanocomposites

L. R. Klauke [1,*], M. Kampferbeck [1], F. C. Klein [1], P. Haida [1], B. Sochor [2], A. Meyer [1], V. Abetz [1,3], T. Vossmeyer [1]
[1] Institute of Physical Chemistry, University of Hamburg, Hamburg, Germany
[2] Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany
[3] Institute of Membrane Research, Helmholtz-Zentrum Hereon, Geesthacht, Germany

Abstract:

Magnetic self-healing nanocomposites based on iron oxide nanoparticles and polymers are of high interest due to their potential applications in sensors and robotics.[1] Additionally, it is possible to fabricate bio-inspired materials based on the same components. Such materials enable high inorganic loadings of up to 95 wt.% and show superior mechanical properties, e.g. high fracture toughness and stiffness.[2]

In our approach, we use a bottom-up strategy for the fabrication of magnetic nanocomposites with multiscale hierarchical structure (Figure 1) based on ceramic nanoparticles. First, we self-assemble superparamagnetic iron oxide nanocubes into 3D supraparticles with sizes between 200-300 nm.[3,4] Second, the surface of the supraparticles is modified using tailored surface ligands or via surface-grafted atom transfer radical polymerization of styrene.[5] The latter enables the integration of functional groups into the polymer shell by using styrene-derived monomers e.g., 4-vinylbenzoic acid, 4-vinylbenzyl azide or 3-vinylphenol. All surface modifications were confirmed via Fourier-transform infrared spectroscopy. Further, via electron microscopy and thermal gravimetric analysis we show that it is possible to precisely adjust the polymer shell thickness by using different monomer volumes. After the polymerization, the maximum at decreased scattering vectors in small angle X-ray scattering experiments revealed swelling of the supraparticles during the formation of polystyrene. Third, 1st hierarchical level supraparticles were embedded into thermoreversible polymer networks to form cm-sized composites.[6] This study improves our understanding of the bottom-up fabrication of bio-imitated materials and the relevant surface interactions between the organic matrices and inorganic building blocks.

Keywords: self-assembly, ATRP, magnetic nanocomposites, biomimetic materials, surface modification, SPIONs.

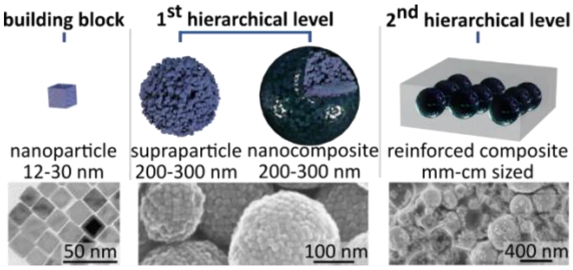

Figure 1: Schematic of the synthetic approach to the bottom-up fabrication of multilevel magnetic composite materials. TEM and SEM images indicating shape and morphology of the different hierarchical levels.

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Unlocking TiO_2's Nanomagnetism: Oxygen Vacancies Lead the Way

V. K. Paidi[1,*,#], B.-H. Lee[2,*], A. T. Lee[3,*], S. Ismail-Beigi[3], E. Grishaeva[1], S. Vasala[1], P. Glatzel[1],
W. Ko[4,5], D. Ahn[6], T. Hyeon[4,5,#], Y. Kim[6,#], K.-S. Lee[6,#]
[1]European Synchrotron Radiation Facility, Grenoble, France
[2]KU-KIST Graduate School of Converging Science and Technology, and Department of Integrative Energy Engineering, Korea University, Seoul, Republic of Korea
[3] Department of Applied Physics, Yale University, USA
[4]Center for Nanoparticle Research Institute for Basic Science, Seoul, Republic of Korea
[5]School of Chemical and Biological Engineering, Seoul National University, Republic of Korea
[6]Pohang Accelerator Laboratory, Pohang, Republic of Korea

Abstract:

Oxygen vacancies play a critical role in influencing the electronic structure and magnetism of titanium dioxide (TiO_2) nanocrystals, which is essential for various material design applications. In this presentation, I will discuss the influence of oxygen vacancies on the local structure of Ti [1]. Specifically, I will explore how oxygen vacancies impact the electronic structure and nanomagnetism of TiO_2 nanostructures by using precisely controlled single-atom cobalt (Co) incorporated TiO_2 nanocrystals as a model system. Through advanced synchrotron X-ray spectroscopy techniques, we have identified Co substitution for titanium (Co_{Ti}) sites and the formation of Co_{Ti} + V_O (oxygen vacancy) complexes. Our experimental findings, coupled with theoretical calculations, reveal that Co^{2+} ions exhibit room temperature ferromagnetism in a high-spin state. Notably, we observed the absence of trivalent (Ti^{3+}) sites, indicating their negligible role in magnetic stability. Furthermore, our calculations elucidate how the presence of additional oxygen vacancies in TiO_2 significantly enhances the ferromagnetic interactions between Co_{Ti} + V_O complexes [2]. This synthesis, experiments, and theoretical calculations establishes a robust framework for advancing our knowledge in designing magnetic materials with single-atom incorporation, paving the way for applications in dilute magnetic semiconductors (Figure 1).

Keywords: Nanocrystals, electronic structure, chemical bonding, oxygen vacancies, X-ray absorption spectroscopy, X-ray emission spectroscopy, first-principles calculations, single-atom incorporated nanostrucutres, dilute magnetic semiconductor applications.

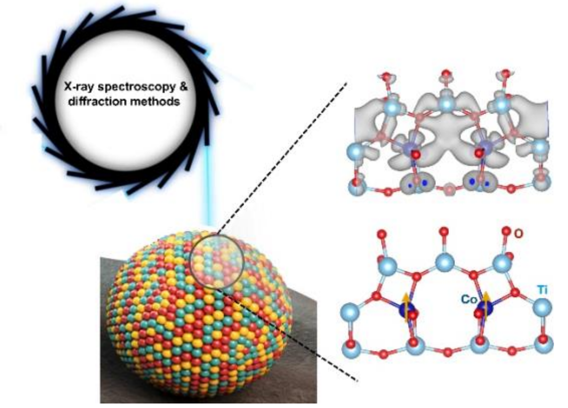

Figure 1: A schematic of the local structure modification of single-atom incorporated TiO_2 nanocrystals. This research shows how a combination of synthesis, advanced spectroscopy experiments, and density functional theory calculations can shed light on oxygen vacancies guided electronic structure and nanomagnetism for applications in dilute magnetic semiconductors.

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2. V. K. Paidi et al., (2024) Revealing the correlation between oxygen vacancies and magnetism in single-atom incorporated TiO_2 nanostructures, *(In preparation).*

*Equal contribution, # Corresponding authors

Functionalization of natural zeolite Clinoptilolite with AgNPs via green *in situ* reduction

F. Gattucci [1,*], M. Lallukka [1], N. Grifasi[1], M. Piumetti[1], M.Miola[1]
[1] Department of Applied Science and Technology, Politecnico di Torino, Turin, Italy

Abstract:

Amidst the global focus on reducing airborne pathogens and ensuring clean air, natural zeolites have gained attention as potentially effective solutions owing to their remarkable adsorption capacity for toxic compounds. Among them, clinoptilolite, widely used in wastewater treatment and air purification, holds substantial promise [1]. The integration of metallic nanoparticles, particularly silver, into the zeolite is one potential option to add antimicrobial properties [2].

In this work, the clinoptilolite powders are functionalized with silver nanoparticles (AgNPs) in order to improve the antimicrobial potential of the zeolite (Figure 1). Notably, the *in situ* reduction of AgNPs is achieved through an eco-friendly process employing tannic acid, a recognized green reducing agent. The focus of this work is the characterization of this multi-step functionalization process by Fourier transform infrared (FTIR), field emission scanning electron microscopy (FESEM) equipped with an energy dispersive X-ray spectroscopy (EDS), elemental mapping, and X-ray diffraction analysis (XRD).

The FTIR analysis confirms the successful functionalization of clinoptilolite with tannic acid, establishing a foundational step in the process. Subsequent FESEM imaging and EDS analysis verify the introduction of AgNPs onto the zeolite, revealing a high uniformity of Ag content dispersed across the zeolite surface. Furthermore, XRD analysis verifies the presence of metallic silver, further corroborating the successful functionalization. Finally, the antibacterial efficacy of Clino-AgNPs was demonstrated to both Gram positive (*Staphylococcus epidermidis*) and Gram negative (*Escherichia coli*) bacteria by zone of inhibition test.

The green synthesis of Ag-functionalized clinoptilolite presents a promising solution to adsorb toxic compounds while simultaneously effectively preventing pathogen growth. In the future, this innovative approach could become a crucial component of air purification systems against airborne pathogens.

This study was carried out within the MICS (Made in Italy – Circular and Sustainable) Extended Partnership and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.3 – D.D. 1551.11-10-2022, PE00000004). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

Keywords: antibacterial, silver nanoparticles, clinoptilolite, tannic acid.

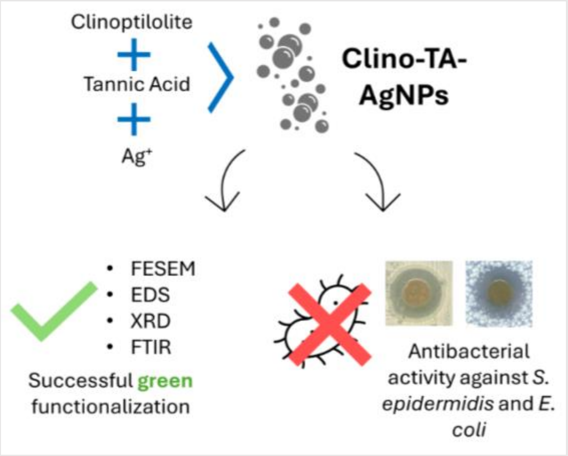

Figure 1: Clinoptilolite successfully functionalized with AgNPs via TA green *in situ* reduction (Clino-TA-AgNPs) demonstrates antibacterial activity against both gram-positive *E.coli* and gram-negative *S.epidermidis.*

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The internal photoluminescence quantum yield and radiative lifetimes of silicon quantum dots

K. Kůsová [1,*], T. Popelář[1], P. Galář[1], F. Matějka[1], J. Kopenec[1]
[1] Institute of Physics, Czech Academy of Sciences, Prague, Czechia

Abstract:
Silicon quantum dots (QDs) are a promising class of light-emitting materials with low inherent toxicity, good material availability and thus interesting application prospects. In contrast to traditional QD materials such as CdSe based on ionic crystals, in which quantum confinement effects are known to induce spectral shifts in emission spectra, the electronic properties of covalently bonded silicon QDs are influenced to an even greater extent, because in silicon quantum confinement effects have the ability to boost the radiative recombination rates by many orders of magnitude and, literally, light it up. This sensitivity to quantum confinement can potentially lead to a very broad tunability of optical properties of Si QDs, but, on the other hand, it complicates the understanding of all the nuances of their photoluminescence dynamics. Besides, having a high melting point, SiQDs cannot be easily synthesized by traditional wet chemistry approaches and one of the most promising fabrication methods is thus the synthesis in non-thermal plasma.

In this contribution, we will discuss the optical properties of two types of SiQDs. First, we will show that the radiative lifetimes of SiQDs with long-lived photoluminescence (PL) are universal regardless of the type of sample. This observation enables us to quantify the internal PL quantum yield of an SiQD sample and thus the extent of the influence of dark QD on the PL properties.[1] Second, we will discuss the possibility of transforming SiQDs into a material with direct-bandgap-like optical properties and bright, short-lived PL via surface-ligand bandstructure engineering.[2] Despite being experimentally demonstrated, this intriguing effect is still not fully theoretically understood and appears to originate in an intricate cooperation of quantum confinement effects and physical and chemical properties of surface ligands [3]

Keywords: quantum dots, silicon, photoluminescence, surface termination, bandstructure engineering, internal photoluminescence quantum yield, dark quantum dots

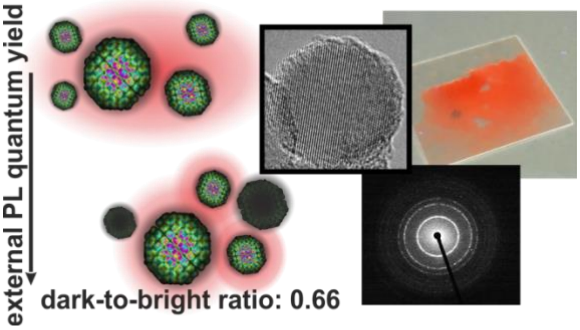

Figure 1: Left: figure illustrating the relationship between photoluminescence external quantum yield and the proportion of dark QDs. Right: an example of an HRTEM and an electron diffraction pattern of SiQDs and a photograph of the luminescing layer of SiQDs under a UV lamp.

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Tailoring Color Appearance with Tunable Disordered Metafilms

Jialong. Peng [1,2,*], Hui Wu, Wei Xu, Biao Yang, Zhihong Zhu [1]

[1] College of Advanced Interdisciplinary Studies and Hunan Provincial Key Laboratory of Novel Nano-Optoelectronic Information Materials and Devices, National University of Defense Technology,
Changsha 410073, China
[2] Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK

Abstract:.

Plasmonic metafilms have been widely utilized to generate vivid colors, but making them both active and flexible simultaneously remains a great challenge. We demonstrate large-area flexible active plasmonic metafilms, which show electrically-tunable vivid color dynamics without relying on mechanical deformation or grating-like structures. The flexible active plasmonic metafilms constructed by printing disordered electrochromic nanoparticles onto ultrathin metal films (<15 nm), offering low-power electrically-driven color switching (Figure 1). In conjunction with commercially available printing, metafilms comprising of a monolayer of electrochromic nanoparticles (< 100 nm) can be laid-down uniformly and patterned precisely within each pixel, offering possibilities to make all-printed wearable plasmonic devices including devices such as electronic shelf labels/indicators, electrochromic textiles integrated with clothes, or biochemical sensors for detecting the protonation level in skin sweat. The whole process is lithography-free and thus readily extends to industrial large scale processing tools. In addition, using directional optical effects that can be controlled with this ultrathin mirror configuration, such flexible active plasmonic metafilms can generate electrically controllable omni- or bi-directional color dynamics, which could be used for 'magic-mirror' applications, color-tunable glass, and architectural decoration.

Keywords: plasmoincs, nanoparticles, surface coating, flexible, nano applications.

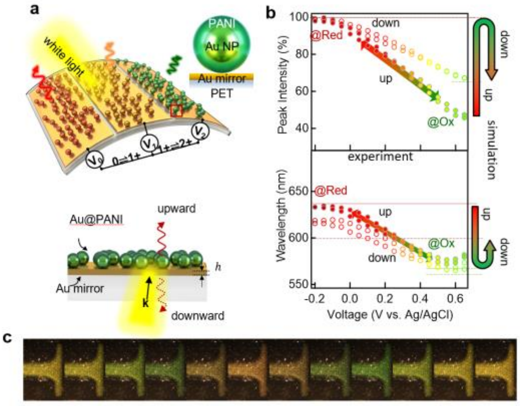

Figure 1: Tailoring color appearance with tunable disordered metafilms. a) Schematic of flexible active plasmonic metafilms with b-c) directional color dynamics.

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Nanotech France 2024 / GAMS 2024 Joint session I. B: Nanomaterials Characterization and Properties

Insights into the degradation mechanisms of nanocatalysts through correlative STEM analysis

A. Garzón Manjón

Abstract:

Proton exchange membrane fuel cells (PEMFCs) are electrochemical devices capable of generating electricity by oxidizing H2, reformate (H2 rich gas with carbon monoxide (CO) impurities) or other fuels. In recent times, metallic core-shell nanoparticles (NPs) (M@Pt, M=Ru, Rh…) have attracted a big interest as anode catalysts of reformate fed PEMFCs [1]. The high catalytic activity of Pt towards the HOR, together with the CO poisoning tolerance introduced by the accompanying metal make them ideal for heavy-duty applications. Furthermore, since in M@Pt NPs the less stable metal (Rh or Ru) is not directly exposed to the electrolyte, their stability is expected to be higher than in the corresponding alloyed NPs, which commonly suffer from dissolution and dealloying [2]. However, M@Pt can still suffer from degradation under fuel cell conditions by processes that are yet not fully understood, which hinders the design of more stable and durable catalysts.

We investigated the degradation behavior of Rh@Pt NPs by means of identical location-scanning transmission electron microscopy (IL-STEM). This quasi in-situ technique allows to overcome the limitations of the ex-situ techniques, in which only statistical general insights are possible, since in IL-STEM the changes of individual particles are tracked between potential cycles. In particular, we characterized the Rh@Pt NPs after 0, 1000, 4000 and 10000 potential cycles (0.06-0.8V, 0.1V/s). Furthermore, since many of the degradation phenomena take place in 3D (e.g., particle migration and corresponding aggregation), selected regions were reconstructed in 3D by means of electron tomography.

We observed particle migration on the carbon support in all the stages of the potential cycling. However, no widespread particle aggregation was observed, even after 10000 potential cycles. A slight Rh dissolution (up to 5 at.%) during the cycles was detected, which decreased as the number of cycles increased. Even though some small particles dissolved during the first 1000 cycles, the main degradation mechanism responsible for the loss of electrochemically active surface area was found to be particle detachment.

Our results indicate that the investigated Rh@Pt NPs present a remarkable stability, and show how IL-STEM can be used for studying the degradation of catalyst NPs.

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A Novel Memristor Design based on Hydrogen Movement on Silicon Surfaces

N. N. Nipu [1*], P. Schubert [1]
[1] Department of Electrical and Computer Engineering, IUPUI, Indianapolis, USA

Abstract:

As edge computing architectures bring processing closer to data sources, there is an increasing need for memory technologies that can work effectively and consistently in a variety of situations while using minimal energy. Memristors are memory devices that have the potential to greatly increase the performance and scalability of edge devices. However, a key challenge is to achieve precise resistance switching. Silicon (Si) surfaces embedded in a proton-conducting polymer can demonstrate controllable memristor behavior wherein hydrogen (H) atoms are deposited onto the surface (Figure 1). When H is inside the polymer, its conductivity decreases. When H is on the silicon surface, its bulk conductivity increases due to more mid-gap traps. Migration of H atom placement can make a memristor unit cell. This study investigates the critical function of H atoms by deliberately altering their positioning and concentration of silicon-based memristor devices. Using the Large-scale Atomic/Molecular Massively Parallel Simulator (LAMMPS), we investigate the impact of temperature (T) and electric field (EF) on H migration. We define a polygonal volume of Si and deposit H atoms on its top surface. After energy minimization, we apply T and EF to observe diffusion and drift of H atoms. The hopping rate depends on applied T and EF. We thus establish a relationship between the three-dimensional velocity of H and applied T and EF. We simulate several movement pathways of H atoms over time under the influence of varying T and EF acting separately or simultaneously. Therefore, we can determine the required magnitude and direction of EF and T to be introduced to the system to achieve desired H position and concentration. Our approach aims to enhance the functionality of edge computing devices and enable more effective neuromorphic computing to emulate human brain operations. However, the limitations of this study include potential scalability issues and the necessity for precise control over hydrogen dispersion. Despite these challenges, the research provides valuable insights on how to modify the electrical characteristics of memristors, offering a way forward in the development of advanced silicon based electronic devices.

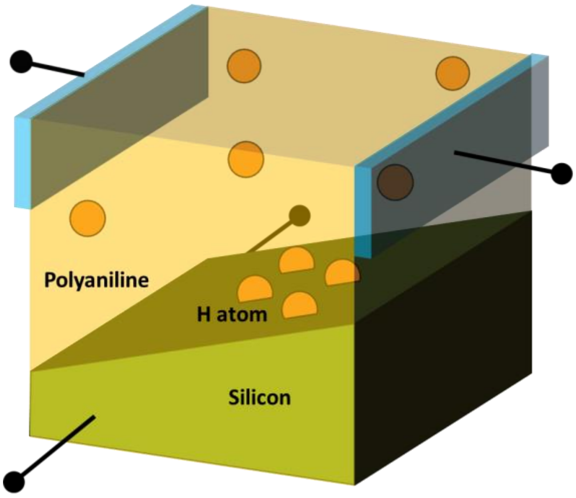

Figure 1: Polymer/silicon memristor unit cell with row and column access to support arrays and complex circuit designs. (Silicon: green, Polyaniline: yellow, Hydrogen atom: Orange circle)

Keywords: hydrogen migration, LAMMPS, memristive properties, resistance manipulation, edge computing, neuromorphic computing.

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Scalar topological photonic meta-crystals

B. Yang [1,*]
[1] College of Advanced Interdisciplinary Studies, National University of Defense Technology, Changsha, China

Abstract:

Topological photonics is an emerging and rapidly expanding field. Air is the most ubiquitous background and is the ideal media for probing various electromagnetic topological surface states and implementing the corresponding device applications. However, conventional photonic surface modes have a low-quality factor in the light cone. Thus, different from electronic systems, electromagnetic topological surface modes inside the light cone can leak into the air. Here we experimentally demonstrate the concept of scalar topological photonic crystals, with surface states exhibiting skyrmion-like electric field distribution, enabling the existence of high Q-factor topological surface states inside the light cone continuum. Our system, with vector-wave eigenvectors, ideal scalar-wave-like bulk dispersion and skyrmion surface states, will be a conceptually advanced platform to innovate topological photonics.

Keywords: topological photonics, scalar wave, surface states, Weyl points, one-way propagation, coaxial cable, metallic structure, 3D printing, topological semimetal, space group, meta-crystals.

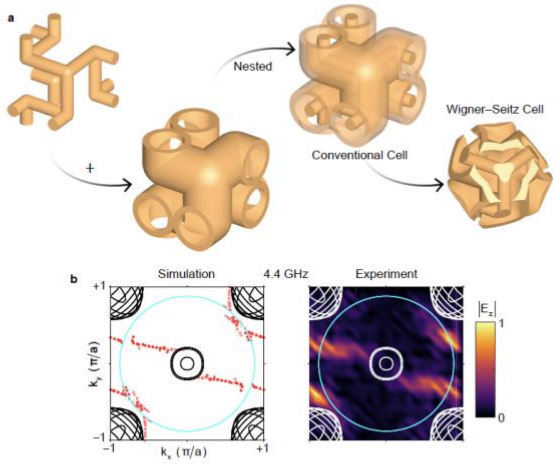

Figure 1: Experimental observations and theoretical simulations of skyrmion textured topological surface states. a, The structure of the nested meta-crystals constructed using connected coaxial waveguides. b, Topological surface states (at 4.4 GHz) are both theoretically simulated (left) and experimentally observed (right) to exist within the light cone (cyan circle).[1]

References:

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Microstructural Effects of Microballistic Impact on Nacre-Like Graphene-Polyethylene Nanocomposites: Exploring the Influence of Hierarchy

Param Punj Singh [1,*], Raghavan Ranganathan [2]
[1,2] Department of Materials Engineering, Indian Institute of Technology Gandhinagar, Gandhinagar, India

Abstract:

In recent years, there has been a growing interest in the utilization of biological structural materials for advanced impact-resistant applications. *Nacre*, also known as the "mother of pearl" is the iridescent layer found in the mollusk shells and distinguishes itself as an exceptional armor material due to its remarkable toughness, thanks to its highly organized "brick and mortar" hierarchical structure. In this study, all-atom molecular dynamics (MD) simulations are employed to investigate the impact resistance of graphene-polyethylene nanocomposites modeled after nacre's microstructure (see Figure 1). Our study is primarily focused toward microballistic impact analysis, aimed at elucidating the impact-resistant characteristics, with particular emphasis on the effects of the graphene grain size within the nanocomposite. Moreover, the impact analysis also delves into the influence of (a) grafting between the graphene grains and the polymer, and (b) the hierarchical staggered structure of the nanocomposite. Furthermore, a comprehensive study of the underlying molecular mechanisms dictating deformation behavior is undertaken. This study augments our understanding of the intricate interplay between structural configurations and material properties in biomimetic impact-resistant materials, thus providing invaluable insights pertinent to innovative material conceptualization and engineering applications.

Keywords: Molecular Dynamics, Nacre-inspired materials, Graphene-polyethylene composite, ballistic impact, Specific penetration energy, Energy dissipation

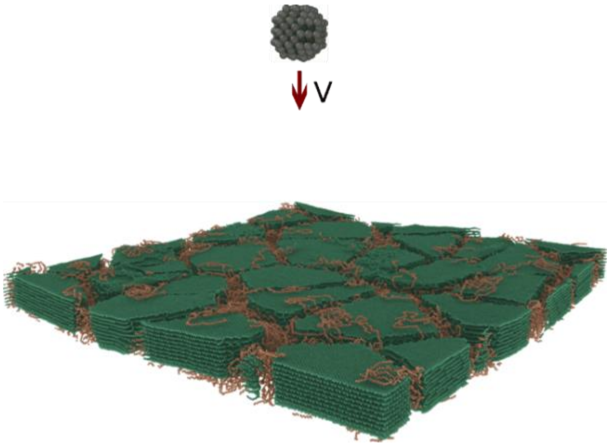

Figure 1: Snapshot illustrating the MD microballistic impact model of nacre-inspired graphene-polyethylene nanocomposite.

References:

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Antibacterial and Photocatalytic Properties of Hydrothermally Synthesized ZnO Nanowires

S. Abou Zeid [1,*], A. Perez [2], S. Rossano [2], and Y. Leprince-Wang [1]
[1] ESYCOM, CNRS-UMR9007, Université Gustave Eiffel, F-77454 Marne-la-Vallée, France
[2] LGE, Université Gustave Eiffel, F-77454 Marne-la-Vallée, France

Abstract:

The escalating difficulty over antibiotic resistance necessitates the exploration of alternative antibacterial strategies.[1] Acknowledging this pressing concern, our study delves into the exploration of ZnO nanowires (ZnO NWs) as a formidable solution. Employing a bottom-up hydrothermal synthesis technique, we successfully crafted uniform and vertically aligned ZnO NWs (Figure 1) characterized by a mean diameter of 45 nm and a length of about 1.5 µm, exhibiting a density of approximately 115 per µm^2.[2] Through comprehensive analysis, including scanning electron microscopy (SEM) and UV-visible spectroscopy, we elucidated the morphological and optical attributes of the synthesized ZnO NWs, showcasing not only their structural integrity but also a distinct optical band gap of 3.22 ± 0.01 eV.[2]

In assessing the multifaceted utility of ZnO NWs, our study uncovered their phenomenal photocatalytic efficacy under UV light, as evidenced by their ability to completely degrade the model pollutant, MB, within a remarkable timespan of 2 hours (Figure 2).[2] Furthermore, our study unveiled the potent antibacterial properties of ZnO NWs, particularly against the Gram-negative bacterium *Pseudomonas putida* (Figure 3). This inhibitory effect stemmed from the unique interplay of three crucial mechanisms: direct interaction with bacterial cell membranes, the release of Zn^{2+}, and the generation of reactive oxygen species (ROS), all of which contributed significantly to the observed antibacterial efficacy, even in the absence of UV light.[2]

These findings underscore the vast potential of ZnO NWs as a versatile material with noteworthy photocatalytic and antibacterial activities, paving the way for a range of applications, particularly in fields demanding efficient antibacterial properties.

Keywords: ZnO nanowires, hydrothermal synthesis, antibacterial activity, photocatalysis, nanomaterial coatings.

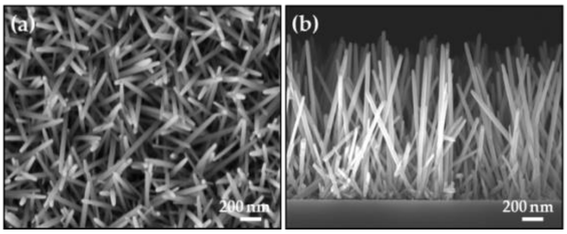

Figure 1: Morphological characterization of ZnO NWs grown on a Si substrate at 90 °C for 3 h via a two-step hydrothermal method. Top-View (a) and Cross-Sectional View (b) SEM images.

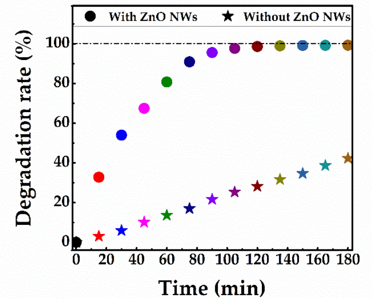

Figure 2: Degradation rate curves of the MB dye under UV light with and without ZnO NWs.

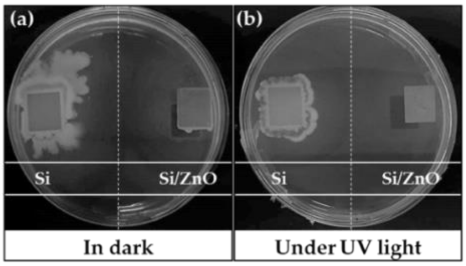

Figure 3: Photographic evidence of antimicrobial activity against *P. Putida* by prepared ZnO NWs on bare Si: (**a**) in the dark and (**b**) under UV light utilizing the printing method.

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Metabolomic Pathways of an Acrylic Resin Enriched with AgNPs as a Proposal for Orthopedic Aparatology

Christian Andrea Lopez-Ayuso[1*], Hiroshi Sakagami[2], Masahiro Sugimoto[3], Rene Garcia-Contreras[1], Ravichandran Manisekaran[1], Mario Figueroa[4], Manuel Rangel-Grimaldo[4], Laura Susana Acosta-Torres[1].

[1] Interdisciplinary Research Laboratory (LII). Nanostructures and Bionanomaterials Area, Escuela Nacional de Estudios Superiores (ENES), Universidad Nacional Autónoma de México (UNAM), León, México.
[2] Meikai University. Research Institute of Odontology (M-RIO), Saitama, Japan
[3] Institute for Advance Biosciences, Keio University, Japan
[4] Facultad de Química. Universidad Nacional Autónoma de México (UNAM), CDMX, México

Abstract:

In Mexico, 60% of the school population between 6 and 9 years of age has some dental malocclusion. To correct these abnormal alignment, orthopedic appliances made of polymethylmethacrylate (PMMA) are used. However, scientific evidence has shown that this appliance can increase the concentration of microbial biofilms. Thus, modern dentistry has leads to improvement in both biomechanics and biocompatibility of materials. Nanoscale materials have demonstrated that they can penetrate the biological membranes of bacteria and inhibiting the cellular function of microorganisms in eukaryotic cells still needs to be fully elucidated. Therefore, this work aimed to to identify the metabolomic pathways in HGFs exposed to AgNP-enriched self-curing PMMA acrylic resin as a proposal for orthopedic devices. We report the standardization, biosynthesis, and characterization of AgNPs obtained from P*elargonium* x *hortorum*, their incorporation into a self-curing acrylic resin with a concentration of 10 µg/mL, which established an antibiofilm effect against *Streptococcus mutans* with biocompatible characteristics, as well as a multi-omic analysis of HGFs using metabolomics (Figure 1). This study will allow us to discuss the mechanism of action of AgNPs, the physicochemical and biological properties of AgNP-enriched PMMA, and its potential clinical application in dentistry.

Keywords: silver nanoparticles, green synthesis, plant extract, human gingival fibroblast, polymethylmethacrylate, antibiofilm, *S. mutans*, biomaterials, nanomaterials, metabolomics.

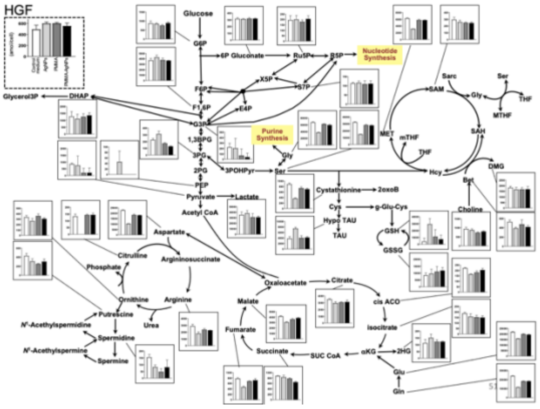

Figure 1: Figure illustrating the fundamental question that we are tempting to solve experimentally: The figure depict the metabolomic pathways are activated or inactivated in HGFs when in contact with the nanocomposite PMMA-AgNPs.

References:

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Nonlinear Optical Properties of Two-Dimensional Materials – A Study on their Suitability for Laser Protection Applications

S. Dengler [1, *], M. Henrichsen [1]
[1] Department Optronics, Fraunhofer IOSB, Ettlingen, Germany

Abstract:
The demand for efficient protection of the human eye and sensitive devices and optics from laser radiation is constantly growing due to the increasing use of lasers with different wavelengths in all areas of life.

One potential method of protection can be realized by using nonlinear optical materials, if they have the ability to limit the transmitted energy. The so-called optical limiting is a nonlinear optical process where material properties change with increasing energy density of laser radiation in such a way that the transmitted energy density remains almost constant over a wide range of irradiated power (Figure 1). Hence, a linear relationship between input and output energy exists only at low energy densities. Currently, there is no material that fully satisfies the requirements for optical limiting applications, particularly for eye protection. The ideal material should have a low threshold, provide sufficient attenuation and be efficient across a broad range of wavelengths. Therefore, research is ongoing to find new materials with improved optical limiting efficiency and to enhance the properties of established optical limiting materials.

In recent years, two-dimensional materials, especially graphene and graphene oxide have received significant attention due to their unique optical properties and potential applications in various fields, including optical limiting [1].

In this work a comprehensive study on the nonlinear optical response of dispersed graphene oxide, boron nitride nanosheets, molybdenum disulfide nanosheets and tungsten disulfide nanosheets is presented. Additionally, nanohybrids were generated by functionalizing the nanosheets with zinc tetraphenylporphyrin. The optical limiting behavior is characterized by means of nonlinear transmittance and scattered energy measurements using nanosecond laser pulses at 532 nm.

Our investigations reveal a strong nonlinear optical effect in graphene oxide, molybdenum disulfide nanosheets and tungsten disulfide nanosheets. The optical limiting properties of graphene oxide and tungsten disulfide could be enhanced by adding zinc tetraphenylporphyrin. This makes these two samples particularly suitable for laser protection applications.

Keywords: nonlinear optical properties of two-dimesional materials, optical limiting, laser protection, nonlinear scattering, nonlinear absorption

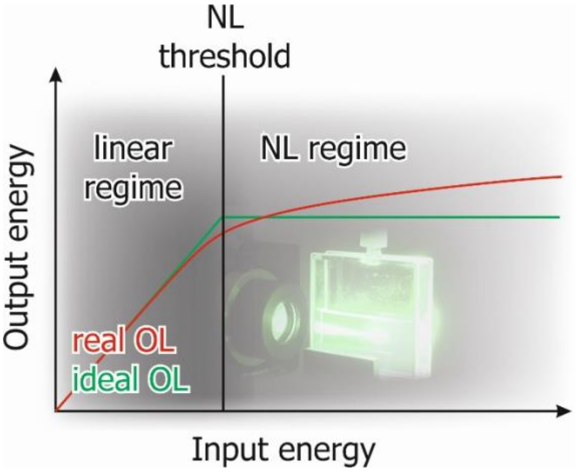

Figure 1: Schematic drawing illustrating ideal and real optical limiting performance.

References:

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Analytical Prediction of Nanoparticle Traffic Jams during Electroketic Treatment of Hardened Concrete

H. Zhong, H. Cardenas
Department of Mechanical Engineering, Louisiana Tech University, Ruston Louisiana, USA

Abstract:
In this work, a Front Area Ratio (FAR) model was developed to estimate the electrokinetic nannanoparticle treatment time and to assess related risks to suspension stability. The possitively charged silica paticles (24 nm) can form a traffic jam if their volume flow rate exceeds the pore size distribution of the concrete surface. These high concentrations of suspended particles can be relatively susceptible to instability, rendering a give treatment to be inefficient or ineffective.

Compared with chemical grout, fiber wrap, and other repair technologies, electrokinetic nanoparticle treatment (EN) exhibits interesting possibilities. EN treatment has been shown to be a simple, effective approach for enhancing mechanical and durability properties, even when particles have exhibited instability during treatment.

A simple assessment of this traffic jam likelihood was done by comparing the surface area of the approaching particles to the surface area of pores that could receive them. The following sections present the derivation of a model that enables this assessment.

The "frontal area ratio" (F_{AR}) of approaching particles with respect to available concrete pores is a dimensionless criterion for predicting a particle traffic jam at a concrete surface that is being treated. It is given by:

$$F_{AR} = \frac{(1+P_A)^2\left(\frac{3}{4}f_P\sqrt{\pi}\right)^{\frac{2}{3}}}{P_{AR}} < 1\ (to\ avoid\ particle\ traffic\ jams)$$

where:
P_A = Decimal fraction of surface pores that are smaller than the nanoparticle size,
f_P = Decimal volume fraction of nanoparticles in the treatment suspension,
P_{AR} = Decimal fraction of concrete surface occupied by pores (approximated using the porosity).

Keywords: nanoporous, silica, concrete, electrokinetic nanoparticle treatment, efficiency, modeling, construction applications.

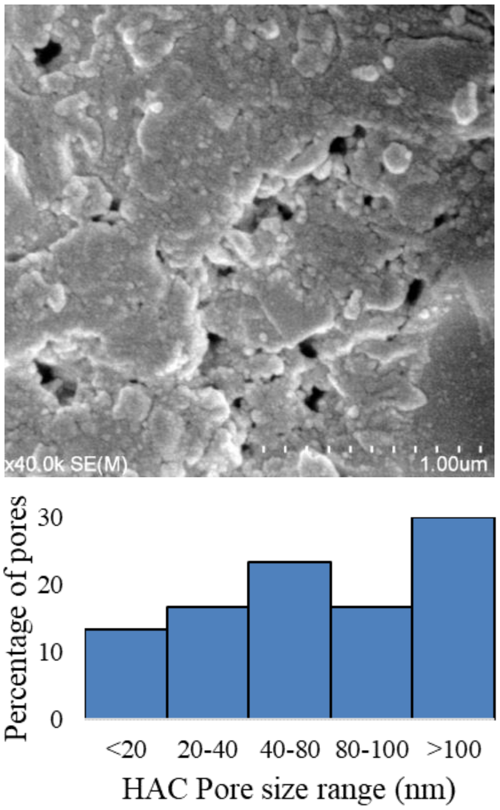

Figure 1: Field Emmission Scanning Electron Micrograph of high alumina concrete, followed by its pore size distribution profile (Used to obtain P_{AR} for model). This work is exploring the use of pore size access modelling to predict the formation of electrokinetic nanoparticle traffic jams that can lead to paticle instability during treatment.

References:

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Smaller pattern size increase mechanical performance and improves stress distribution in parts designed using 3D mass reduction method bio-inspired from trabecular form-function relationship

N. Cadoret [1,2], J. Chaves-Jacob [2,*], M.-A. Celli [1], J.-M. Linares [2]
[1] Airbus Helicopters, Aéroport de Marseille Provence, Marignane 13700, France
[2] Aix Marseille Université, CNRS, ISM, Inst Mouvement Sci, UMR 7287, Marseille, France

Abstract:
Sustainable practices and the pursuit of optimal strength-to-weight ratios in mechanical engineering have become increasingly important. Consequently, natural materials with high strength-to-weight ratio have gained attention for bio-inspiration [1]. Among natural materials, trabecular bone is known as a material whose form adapts to its mechanical function. Previous research introduced a 3D bio-inspired mass reduction method (3DBIMR) based on the form-function relationship of trabecular bone [2]. Specifically, a stress-driven algorithm based on bio-inspired laws is used to generate a bio-inspired porous architecture that mimics trabecular bone. However, in 3DBMIR, the architecture's pattern size p is based on a law that reproduces the trabecular allometric scaling [3]. This allometric scaling is the consequence of multiple biological phenomenon that are not all relevant to mechanical behavior. Here we show that, on a macro level decreasing p in 3DBIMR increases mechanical performance up to a plateau, and at a micro level further decreasing p helps improve the stress distribution in the porous architecture. These results tend to confirm that trabecular allometric scaling is not only dictated by mechanical constraints because macro performance do not increase past a certain plateau which appears before hitting the bio-inspired pattern size. The better stress distribution could help increase the performance of bio-inspired porous architecture in fatigue applications. These results have consequences for the design of bio-inspired implants that limit stress shielding by improving stress distribution as well as bio-inspired additive manufacturing parts for fatigue applications in industries with high demands such as aerospace.

Keywords: cellular materials, trabecular bone, form-function relationships, bio-inspired mass reduction

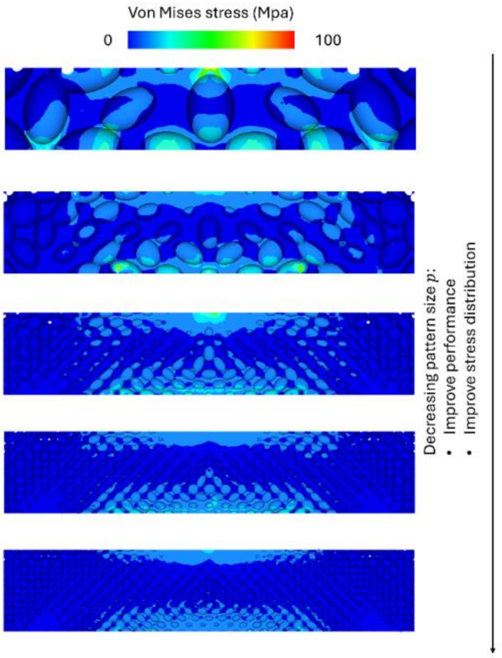

Figure 1: finite element results showing the Von Mises stress in 5 different 3-point bending beams with diminishing pattern size. This demonstrates that smaller pattern sizes help improve mechanical performances and improve stress distribution throughout the 3D bio-inspired mass reduced architecture.

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X-Ray Fluorescence Imaging and Defect Cluster Map Enhancement in Metal Photopolymer Nano-Composite Thin Film

Meenakshi Arya[1,4*], Aswani Yella[1], Gagan Kumar[2], S.R. Kasture[3], Ch. Vandana[4], Apurva Kumari[4], B R Sanjeeva Reddy[4], Padma Vasavi Kalluru[5], Sumalatha Madugula[5], and Siddhartha P Duttagupta[1]

[1] Centre for Research in Nanotechnology and Science, Indian Institute of Technology Bombay, Powai, Mumbai, PIN 400076, India
[2]Department of Physics, Indian Institute of Technology Guwahati, Assam, PIN 781039, India
[3]Government Polytechnic Mumbai, Bandra East, Mumbai, PIN 400051, India
[4]Department of Electronics and Communications Engineering, BV Raju Institute of Technology, Narsapur, Telangana, PIN 502313, India
[5]Department of Electronics and Communication Engineering, Shri Vishnu Engineering College for Women, Bhimavaram, Andhra Pradesh, PIN 534202, India

Abstract:

This study involves the non-destructive analysis of thin film processed as a composite of copper nanoparticles (Cu-NP) and photopolymer. The objective is to evaluate defect clusters using 2D X-Ray Fluorescence (XRF) imaging coupled with post-processing for improved contrast. First, Cu-NP (particle size < 20 nm) are prepared using a planetary ball milling setup [1]. Next, nano-ink formulation comprising of Cu-NP and photopolymer (SU-8) is realized via ultrasonicator. Following this, spin-coating and thermal bake steps are used to form a 100 nm thick coating (Cu-NP/SU-8) on a glass substrate. The traditional analyses of such composites [2] have focused on tunable optical properties such as complex refractive index. In this study, we follow the literature on XRF imaging [3, 4] and extend the same for monitoring defects. High resolution (micron-scale) spatial maps are generated using XRF spectroscopy. The resultant analyses points to the presence of micron-scale defect clusters (DC). Next, these DC maps have been subjected to a set of post-processing techniques – gamma correction for image enhancement, Gaussian blurr for image noise reduction, and Sobel edge detection for better image contrast. The rapid pattern recognition of DC maps will help support accelerated process flow design and optimization of nano-composite thin films.

Keywords: 2D X-Ray Fluorescence Imaging, Cu-NP/SU-8 Ink, Defect Cluster Map. Image Processing Algorithms.

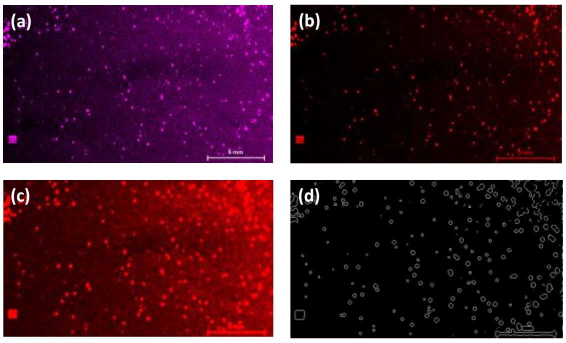

Figure 1: (a) Original XRF image of Cu-NP based nano-composite thin film, **(b)** Applying gamma correction to 1(a) for image enhancement, **(c)** Applying Gaussian blur to 1(b) for image noise reduction, **(d)** Applying Sobel edge detection to 1(c) for better image contrast.

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Passive silicon optical isolator based on free carrier dispersion effect

W. Xu [1,2,] , Q. Hong [1,2], G. Xia [1,2], P. Xu [3*], Z. Zhu [1,2*],
[1] *College of Advanced Interdisciplinary Studies & Hunan Provincial Key Laboratory of Novel Nano Optoelectronic Information Materials and Devices, National University of Defense Technology, Changsha, 410073, China
[2] Nanhu Laser Laboratory, National University of Defense Technology, Changsha, 410073, China
[3] *Institute for Quantum Information and State Key Laboratory of High-Performance Computing, College of Computer Science and Technology, National University of Defense Technology, Changsha, 410073, China.

Abstract:

Non-reciprocal devices, including isolators and circulators, play a pivotal role in on-chip applications. Comparing with approaches that involve the integration of magneto-optical materials and spatiotemporal modulation, nonlinear non-reciprocaldevices exhibit distinct advantages. We report that the free carrier dispersion (FCD) effect in silicon is exploited to achieve the pulsed light isolation on chip. We design a non-reciprocal structure that comprises a microring and a side-coupled waveguide, accompanied by an asymmetric scattering unit. Spectral measurements for forward and backward directions in continuous wave (c.w.) laser is performed respectively to show a non-reciprocal transmission ratio (NTR) as high as 25 dB, with insertion loss less than 1.65 dB. Furthermore, the experimental test of bidirectional pulse light has demonstrated excellent isolating ability of the proposed structure, as long as the peak power did not exceed 2 W. In particular, a chip-scale LiDAR system is constructed around the proposed structure, allowing for range measurement and isolation of reflected light simultaneously. This low-cost, easyscalability and bias-free silicon isolator carries unique advantages for cost-sensitive applications such as automotive grade light detection and range (LiDAR), optical communication, and all optical neural network.

Keywords: silicon optical isolator, free carrier dispersion, light detection and range.

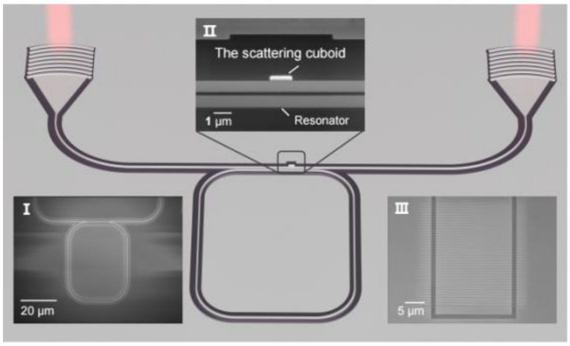

Figure 1: The schematic of the proposed structure. Inset I: The SEM image of the overall view of the fabricated device. Inset II: The SEM image of an enlarged view of the scattering cuboid. Inset III: Grating couplers to couple in/out the light from a fiber to the chip.

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Opuntia Ficus-indica extraction based anticounterfeiting tag functioning at Optical and Terahertz band

S. K. Sighano[1,2*], T. Ritacco[4], M. D. L. Bruno[1,3], O. Gennari[3], W. Fuscaldo[4], D.C. Zografopoulos[4], R. Beccherelli[4], T. Maurer[2], Roberto Caputo[1,3,5] and A. Ferraro[3]
[1] Physics Department, University of Calabria, Rende (CS), Italy
[2] Light, Nanomaterials, Nanotechnologies (L2n), Université de Technologie de Troyes, 12 rue Marie Curie, 10004 Troyes Cedex, France
[3] Consiglio Nazionale delle Ricerche - Istituto di Nanotecnologia (CNR-Nanotec), Rende (CS), Italy
[4] Consiglio Nazionale delle Ricerche - Istituto di Microelettronica e Microsistemi (CNR-IMM), Roma, Italy
[5] Institute of Fundamental and Frontier Sciences, University of Electronic Science and Technology of China, Chengdu 610054, China

Abstract:

Anti-counterfeiting methods[1] are developed in response to the counterfeiting activities that continue to cause damage around the world. Several approaches are emerging for the fabrication of new anti-counterfeiting tags, combining the use of new techniques and materials, in order to make it more difficult to reproduce. We propose a novel technology, using cheaper materials and a simple fabrication process, while increasing levels of security.

We used Opuntia Ficus-indica (OFI) plant extract, with its distinctive fluorescent properties as a key material to provide the first security level of the tags. Indeed, it show a distinctive red emission when excited with UV light source. Polyvinyl alcohol (PVA)[2] was combined with titanium dioxide (TiO2) to realize a flexible substrate that can be easy integrated on product packaging. The OFI fluorescent extract was mixed with polymethyl methacrylate (PMMA) and sprayed on the substrate to realized not deterministic deposited fluorescent droplets. We fabricated 10 tags and then we took three photos of each tag at three angles: 0°, 45° and 90°. Scale Invariant Feature Transform (SIFT) image recognition algorithm is used to analyze these photos and recognized unique features. The analysis shows that a range of 130 to 1502 features is recognized when a tag is compared to itself whatever the angle taken. Instead of a maximum of 16 features being detected when two different tags are compared, namely at least one order of magnitude lower. Higher number of features makes the tag stronger and more difficult for counterfeiters to reproduce.

A logo undetectable in the visible spectrum has been sputtered to the anti-counterfeit tags to provide a second level of security. It consists of a 6-square patch array of 25 nm thickness of indium tin oxide (ITO)[3]. This logo is visible in terms of reflection in terahertz spectroscopy[4] at 0.3-10 THz frequency range. Thanks to the transmission line circuit model[5–7], the evaluation of the reflectance behavior of the ITO shows that each patch array in the logo has a unique and unpredictable response because of its distinct electro-optical characteristics. Due to the difference in their thickness caused by the fluorescent dots on the substrate, the different patches are then unique. Thus, it would be impossible to reproduce them, giving an anti-counterfeiting tag which are doubly protected and impossible to replicate.

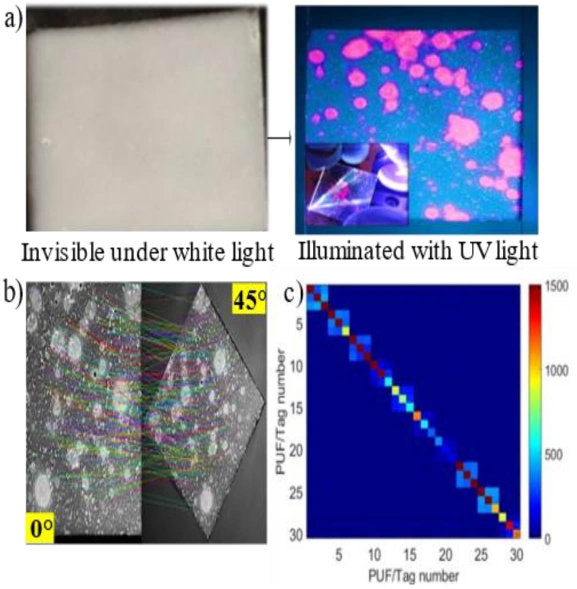

Figure 1: First level of security of tags. a) Random dispersion of fluorescent OFI-PMMA droplets and illumination with a UV light. b,c) Tag photo (0°) compared with itself at 45° using sift algorithm and correlation matrix map of 10 anticounterfeiting tags (30 photographs).

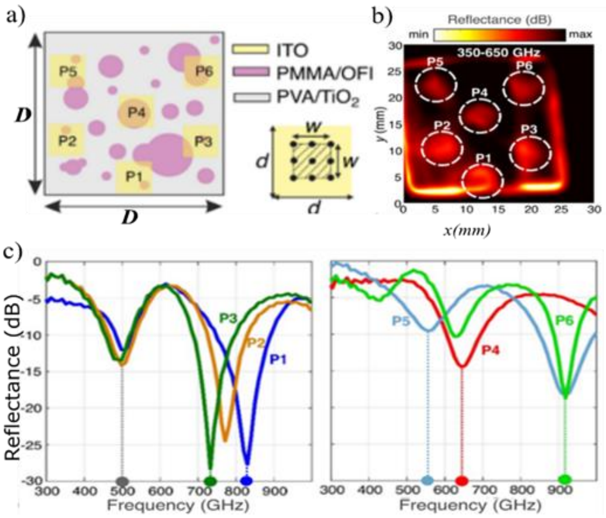

Figure 2: Tags second level of security. a) Scheme of the square sample showing the different elements forming the tag. b) Reflectance imaging integrated in the 0.35-0.65 THz range, showing the logo composed of the six patches. c) Reflectance spectra of the patches P1, P2, P3, P4, P5 and P6 in the 0.3-1.0 THz frequency-domain.

These low-cost anti-counterfeiting tags will help producers to protect their works easily. For the first level of security, it is only necessary take a photo with a smartphone, therefore consumers could easily verify the authenticity of products. by comparing the taken photon with the one stored into the database. Indeed, they can use a specific application to compare the taken photo with the one stored into a secure database. The second level requires advanced instrumentations and high skill therefore it is accessible only to expert in case of doubt on the first level.

Keywords: Anticonterfeiting tags, fluorescent material, UV light excitation, image recognition algorithm, terahertz spectroscopy, flexible substract, transmission line circuit model, microdroplets, security applications.

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Quantifying Microstructural Evolution in Cyclically Loaded NiTi SMAs: Advancing Fatigue Criterion through Stored Energy Analysis

Xiaofei Ju [1,2], Ziad Moumni [1,*], Andras Borbely [3]
[1] UME, ENSTA-Paris, Institut Polytechnique de Paris, France
[2] School of Mechanical & Aerospace Engineering, Nanyang Technological University, Singapore
[3] Mines Saint-Etienne, Université de Lyon, CNRS, France

Abstract:

Pseudoelastic shape memory alloys (SMAs) are recognized for their unique characteristics like the shape memory effect and superelasticity, making them promising in various applications. However, their fatigue behavior, complicated by a reversible martensitic transformation, is intricately tied to their microstructural evolution—an aspect not addressed by current fatigue criteria based on macroscopic parameters. [1]. During cyclic process, part of the hysteresis work is dissipated into heat, while the remainder is stored in dislocations. The stored energy increases with accumulated dislocation and eventually leads to the crack formation when it reaches a critical value. Accordingly, the stored energy is regarded as appropriate fatigue criterion from theoretical perspectives. However, in the domain of SMAs, the stored energy is not yet widely considered in the fatigue analysis [2]. This study offers a quantitative analysis of cyclically loaded NiTi SMAs, with a focus on the localization and evolution of stored energy as a fatigue indicator. We propose using microstrain, derived from the Williamson-Hall plot analysis of peak broadening compared to a non-deformed sample, to determine the stored energy as a quantity accounting for microstructural changes. This approach advances the understanding of fatigue in SMAs and contributes to the development of a physically based fatigue criterion, grounded in the quantification of microstructural evolution.

Keywords: shape memory alloys, stored energy, fatigue criterion, X-ray diffraction, Microstructure quantification.

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Exploring the use of GaAsBi alloys as strain-reducing layers in InAs/GaAs QDs.

S. Flores[1], D. F. Reyes[1], V. Braza[1], T. Ben[1], N.J. Bailey[2], M.R. Carr[2], R.D. Richards[2] and D. Gonzalez[1]
[1] Institute for Research into Electronic Microscopy and Materials, (IMEYMAT). The University of Cadiz. Puerto Real (Cádiz), 11510. Spain.
[2] The University of Sheffield, Department of Electronic and Electrical Engineering, Sir Frederick Mappin Building, Mappin Street, Sheffield S1 3JD, UK.

Abstract:

Quantum dot (QD) semiconductor devices, in particular self-assembled InAs/GaAs QDs grown by the Stranski-Krastanov (S-K) process, have the potential to be used in a wide range of applications such as sensing, solar cells, and quantum computing due to their 3D carrier confinement and delta density of states [1]. However, typical GaAs capping only achieves an emission wavelength of ~1100 nm, far from the 1260-1560 nm range where telecom bands emit. The use of strain-reducing layers (SRLs) on InAs QDs, which have a higher lattice constant than GaAs, may allow the emission wavelength of InAs QDs to be extended, and in this sense the use of GaAsBi alloys is an area to be explored. Furthermore, this dilute bismuthide material offers new possibilities for designing novel devices due to its large bandgap bowing, temperature-insensitive bandgap and large spin-orbit splitting [2]. The challenge lies in the need for a low growth temperature (<400 °C) to achieve high Bi concentrations in III-V alloys, far from the typical SRL growth temperatures (~580 °C) where Bi acts as a surfactant without incorporation.

This work explores the implementation of GaAsBi as a SRL on InAs QDs at low temperature (370 °C) using different Bi fluxes, ranging from low (**Bi-L**), medium (**Bi-M**) and high (**Bi-H**) Bi fluxes. The effects were investigated through extensive characterization using multiple (scanning) transmission electron microscopy techniques ((S)TEM). It was found that low-temperature GaAs capping decreases QD degradation (**Ref-LT**), resulting in larger pyramidal dots, but also increases threading dislocation (TD) density. When Bi is added to CL, TD density decreases significantly, but unexpected structural changes occur. First, all GaAsBi layers reach the solubility limit (2.4% Bi) while maintaining a constant thickness that matches the topology of the QD layer. At higher fluxes, the excess Bi does not lead to an increase in Bi content, but to an increase in layer thickness, bringing forward its effective incorporation into the epitaxy, with a decrease in the distance between the wetting layer and the capping layer.

We observed that GaAsBi SRLs led to smaller QDs than Bi-free SRLs because of increased QD decomposition. Interestingly, in the samples with more Bi, an extra InGaAs layer appeared on top of the GaAsBi layer due to the In atoms being carried away by the Bi from the decomposed QDs. However, the samples with the highest Bi flux also showed regions of high segregation, where we detected Bi-free nanowires between CL and WL. These results show unexpected effects of GaAsBi SRLs on InAs QDs, contradicting conventional beliefs about the role of SRLs in quantum dot systems.

Keywords: GaAsBi capping, self-assembled InAs QDs, STEM compositional analyses

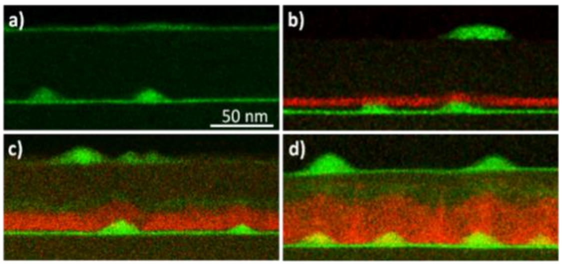

Figure 1: EDX colourmaps for In (green) and Bi (red) distribution of representative zones of samples **Ref-LT**, a); **Bi-L**, b); **Bi-M**, c) and **Bi-H**, d).

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Nanotech France / Biotech France 2024 Joint session I.C

Mechanobiological effects of geometry-mediated wound healing

K. Jimmy Hsia[1,2,*], Hongmei Xu[1]
[1] School of Mechanical & Aerospace Engineering, Nanyang Technological University, Singapore
[2] School of Chemistry, Chemical Engineering & Biotechnology, Nanyang Technological University, Singapore

Abstract

Wound healing through re-epithelialization of gaps is of profound importance to the medical community. One critical mechanism identified by researchers for closing non-cell-adhesive gaps is the accumulation of actin cables around concave edges and the resulting purse-string constriction. However, the studies to date have not separated the gap-edge curvature effect from the gap-size effect. Based on our recent work published in *PNAS* and *PNAS Nexus*, I will discuss a central question in wound healing: how MDCK cells collectively respond to different geometric features. Using micro-printing technology, we generated straight and wavy “wounds” whose size and curvature are varied independently. The results demonstrate that MDCK cell re-epithelization is closely regulated by the gap geometry and may occur through different pathways. Wavy wounds heal much faster than straight ones. In addition to purse-string contraction, we identify gap bridging either via cell protrusion or by lamellipodium extension as critical cellular and molecular mechanisms for wavy gap closure. Cell migration in the direction perpendicular to wound front, sufficiently small gap size to allow bridging, and sufficiently high negative curvature at cell bridges for actin cable constriction are necessary/sufficient conditions for gap closure. Our experiments show that straight stripes rarely induce cell migration perpendicular to wound front, but wavy stripes do; cell protrusion and lamellipodium extension can help establish bridges over gaps of about 5 times the cell size, but not significantly beyond. Furthermore, collective cell migration patterns also play important role in bridging formation. Such mechanobiological understanding of cell responses to wound curvature and size helps guide development of biophysical strategies for tissue repair, plastic surgery, and wound management.

Keywords: wound healing, collective cell migration, actin cable, cell protrusion, lamellipodia extension

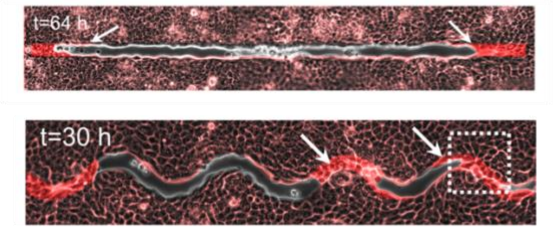

Figure 1: Different non-cell-adhesive surface patterns give rise to different wound healing pathways in MDCK cells. Straight wounds heal from the two ends, leading to slow healing speed; wavy wounds heal by forming bridges at many locations, resulting in fast healing speed. One key difference is the collective cell migration patterns in response to the wound geometry.

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Development and Characterization of New Chitosan-Based Nanofibers for Wound Management

L. Profire[1], O.M. Ionescu[1], A.T. Iacob[1], F.G. Lupascu[1], B.S. Profire[2], S.E. Giusca[3], I.D. Caruntu[3]
[1]Department of Pharmaceutical Chemistry, Faculty of Pharmacy, “Grigore T. Popa” University of Medicine and Pharmacy from Iasi, Romania
[2]Department of Internal Medicine, Faculty of Medicine, “Grigore T. Popa” University of Medicine and Pharmacy from Iasi, Romania
[3]Department of Morphofunctional Sciences, Faculty of Medicine, “Grigore T. Popa” University of Medicine and Pharmacy from Iasi, Romania

Abstract:

Poor wound care does not only unnecesarily extend the time to properly close an acute wound but also adds the risk of the wound becoming chronic (1). Many factors including age of the patient, smoking, malnutrition, obesity and chronic diseases, such as diabetes, can delay wound healing and increase the risk of developing chronic wounds (1). Chitosan-based nanofibers (CS-NFs) are excellent artificial extracellular matrices (ECMs) due to the resemblance of CS with the glycosaminoglycans of the natural ECMs (2). Despide this excellent feature, the poor electrospinnability and mechanical properties of CS are responsible for important limitations in respect to its biomedical applications (3). To improve the CS’s physico-chemical properties, new bioactive and biomimetic CS-NFs, having incorporated different active components (ACs), with important beneficial effects for healing (Manuka honey, propolis, *Calendula officinalis* infusion, insulin and L-arginine) were formulated. The developed nanofibers (CS_PEO-ACs NFs), were characterized in terms of physico-chemical and structural features including, morphology, swelling degree, surface free energy parameters, biodegradation, biocompatibility, cytotoxicity, and were tested for their antioxidant and antimicrobial effects. SEM morphology analysis revealed well-alignment, unidirectional arrays, with small diameters, no beads, and smooth surfaces. The developed NFs showed good biodegradability, increased hemocompatibility, and a reduced cytotoxicity degree. In addition, significant antioxidant and antimicrobial effects were noted for the developed NFs, which make them suitable for chronic wounds, due to the role of oxidative stress and infection risk in delaying normal wound healing. The most suitable for wound healing applications seems to be CS_PEO@P_C which showed an improved hemolysis index (2.92±0.16%), is non-toxic (cell viability degree more than 97%), and has also significant radical scavenging effect (DPPH inhibition more than 65%). In addition, CS_PEO@P_C presents increased antimicrobial effects, more noticeably for *Staphylococcus aureus* strain, which is a key feature in preventing wound infection and delaying the healing process. It can be concluded that the developed CS/PEO-ACs NFs are very promising biomaterials for wound care, especially CS_PEO@P_C.

Keywords: chitosan, nanofibers, biocompatibility, biological effects, wound dressings

Acknowledgement

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Reusable lithium-free multilayer MXene based sorbents for portable dialysis cartridges

E. Precetti [1]

[1] Drexel Nanomaterials Institute, Drexel University, Philadelphia, U.S.A

Abstract:

MXenes are a family of two-dimensional transition-metal carbides and nitrides discovered at Drexel University in 2011[1] with a general formula of $M_{n+1}X_nT_x$, where M stands for an early transition metal (Ti, V, Nb, Mo), X stands in for either carbon or nitrogen, n = 1−3, with Tx representing surface terminations acquired through MXene's top-down etching process such as −OH, −O−, and −F[2]. They are biocompatible, conductive and possess a host of qualities that make them ideal for medical applications.

Herein we demonstrate how a lithium-free NaF Mild method etched $Ti_3C_2T_x$ MXene could serve as the ideal[3,4] adsorbent for the removal of urea and creatinine from a testing solution both in a dynamic adsorption column setup and a kinetic adsorption on small scale samples. While the effectiveness of $Ti_3C_2T_x$ MXenes have already been hinted at[5] and demonstrated[6], this work expands on previous papers[7] and shows improvements to the material and the ability to be re-used to improve any potential sorbent cartridge.

Keywords: dialysis, nanotechnology, MXene, biomedical applications, Drexel, 2D nanomaterials, lithium-free, sorbent, urea, portable dialysis.

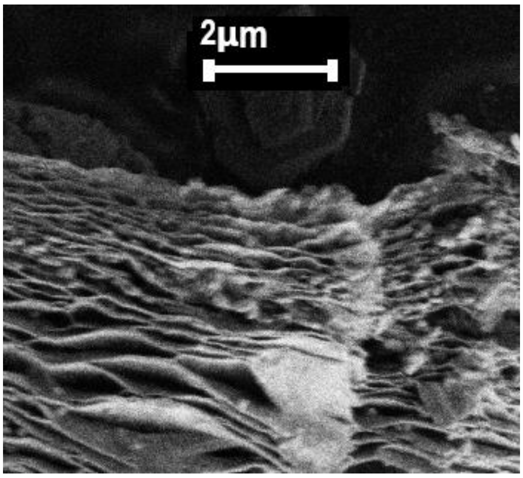

Figure 1: MXene etched using sodium fluoride Mild etching method.

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Synthesis and investigation of properties of conductive nanocomposites for nerve regeneration applications

Aleksandra Sierakowska-Byczek [a], Julia Radwan-Pragłowska [a], Łukasz Janus [a], Julita Śmietana [a]
[a] Cracow University of Technology, Faculty of Chemical Engineering and Technology,
a.sierakowska3530@doktorant.pk.edu.pl

Abstract:
The nervous system is considered the most important in the human body, because it controls the other systems. The basic division distinguishes the central nervous system and the peripheral nervous system. The peripheral nervous system, unlike the central nervous system, can regenerate [1]. In the case of injuries requiring surgical intervention, autologous transplantation is considered the "gold standard", but it is associated with many limitations, among which one can distinguish insufficient tissue availability and additional burden on the body associated with the procedure at the place of collection. Another solution may be the use of nerve canals, but products available on the market have limitations such as supporting the regeneration of only short sections of nerves and lower efficiency compared to autografts [2].

In order to increase the effectiveness of nerve regeneration, nerve channels based on collagen and chitosan were obtained, which were additionally functionalized with Ag, Au, Pt nanoparticles coated with conductive polymers such as polypyrrole, polyaniline and polyvinylpyrrolidone [3,4]. The nerve canals were obtained using electrospinning and 3D printing technology. The morphology of the nanoparticles was investigated using TEM, while the conductive properties were determined by the conductivity method. The physicochemical properties of the obtained nanocomposites, such as chemical structure, swelling capacity, porosity, mechanical strength, were investigated. Biomaterials have also been tested for degradation, biodegradation, antibacterial properties and cytotoxicity.

Keywords: biomaterials; nanofibers; nerve guidance conduits; tissue engineering

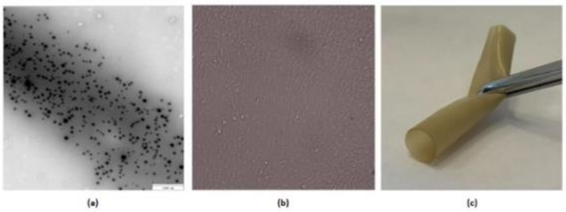

Figure 1: (a) TEM image of Ag/PP nanoparticles; (b) qualitative assessment of cytotoxicity on MG-63 cells after 72 h cell culture; (c) the nerve canal obtained.

This research was funded by Ministry of Education and Science, Diamentowy Grant, grant number 0023/DIA/2020/49.

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Magnesium based bulk metallic glasses for biomedical applications

Rajesh Kumari rajendran[1], Divyanshu Aggarwal, Manon Roland[1], Cosmin Gruescu[1,2], Rajashekhara Shabadi[1]
[1] UMET, Université de Lille, Lille, France
[2]IUT de Lille, France

Abstract:

A system of multicomponent alloys that vitrify easily during solidification are termed as bulk metallic glasses (BMG). They have attracted considerable attention over recent years due to their superior hardness, strength, good damping properties, good corrosion and oxidation resistance. This makes them potential candidates for structural applications. Magnesium and its alloys have the lowest density of all structurally considered materials and are proving to play an increasingly important role in the automotive aerospace and consumer electronics industries as a result of their high specific strength and stiffness. Starting from the works of Inoue and team from 1988 there are a number of BMGs reported so far based on magnesium which deals with its different applications.(Inoue et al., 1988) Among them, the biocompatibility of BMGs is more pronounced due to the single-phase amorphous structure. The absence of secondary phases enhances their resistance towards corrosion and degradation. Mg-Ca-Zn system is one of the best combinations for the biomedical application because Zn and Ca not only improves the hardness of magnesium alloys, but they also offer adequate support to the injured tissue/bone, and are non-toxic too(Jin et al., 2022). Previously, a ternary system based on Mg-Zn-Ca was studied and although the results were promising, the degradation rate was much faster (4 weeks in vivo). For any orthopedic related surgery involving an implant, a minimum of 10 to 12 weeks of healing time is required. The rapid dissolution of Mg-Ca-Zn has limited its application and is the bottleneck in this case. The present research proposes a strategy to improve the corrosion/dissolution and increase its bio-adaptability, by alloying. So, the goal is to produce more biocompatible Mg-Ca-Zn based BMG having better glass forming ability with the addition of new alloying elements.

Keywords: Bulk metallic glass, Magnesium alloy, Corrosion, Biomedical applications.

Figure 1: Image showing the Mg based bulk metallic glass produced through copper mold casting method.

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Use of an Innovative Material for Biotech Applications in Agriculture

M. Rippa[2], E. Lahoz[1,*], M. Cermola[1], P. Mormile[2], V. Battaglia[1]
[1] CREA - Centro di ricerca Cerealicoltura e colture industriali, Via Torrino 3, 81100 Caserta
[2]Istituto di Scienze Applicate e Sistemi Intelligenti "Eduardo Caianiello" del CNR, Via Campi Flegrei 34, 80072 Pozzuoli (Na)

Abstract:
Pesticide treatments are largely used in agriculture in the control of a wide range of biotic stresses. Huge quantity of chemicals is employed in agriculture. Number and interval of treatments depend on plant growth, washout, risk of infection, disease pressure, quality of distribution on leaves, and scheduled application. This cause concern about environment and human health, and an economic impact on farmers activity. Sustainable methods to reduce impact of chemicals pollution and residues on soil and plant should be explored not only with a complete elimination of chemicals but also reducing the amount and number of chemical applications per year, by using new biotech materials that the research world is proposing. Formulation and adjuvants could play an important role in increasing bioavailability and regulate frequency of applications. The addition of an appropriate adjuvant to a foliar fungicide can significantly improve coverage, absorption, efficacy and can reduce the total amount applied in a season. Among different chemicals, polysaccharides, such as chitosan, carrageenan, fucans, laminarins and ulvans have been tested on economically relevant crops, prevalently to investigate their interaction with the plants and the eventual ability to induce resistance to fungal pathogens. Galactomannans are used in edible films or coatings for food make them very interesting for any potential use in agriculture. The results of use of a new natural polysaccharide based on locust bean gums (Lerigel) is presented and, according to interesting results of our trials, it is proposed for different biotech application, ranging from reduction of chemical treatments to seed coating and application on plant with beneficial microorganisms. In particular, the results of experimental use of Lerigel both as adjuvant in copper fungicide applications and formulant for beneficial microrganisms are reported. Data demonstrated that: i) the use of this natural adjuvant increase persistence on leaves of copper fungicides reducing the amount of copper need to control *Plasmopara viticola* on grape and ii) increase the efficacy and actvity of the beneficial microrganisms such as *Trichoderma* spp. and *Clonostachys rosea* as seed coating on wheat.

Keywords: Biotech materials, polysaccharide, BCAs formulant, seed coating.

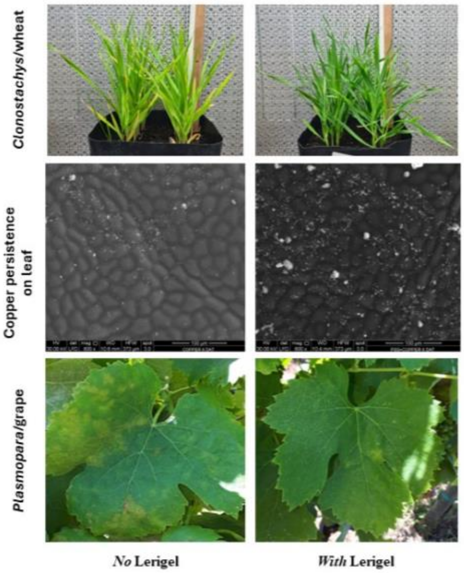

Figure 1: Figure illustrating the activities of polysaccharide (Lerigel) as adjuvant in seed coating on wheat with biological control agents (on the top), and in copper fungicide applications in vineyard

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Methane conversion into methanol by *M. trichosporium* OB3b: Investigating the bioprocess limitations and solutions.

H. Baldo, A. Ruiz Valencia, L. Cornette de Saint Cyr, E. Petit, J. Sanchez-Marcano, M.P. Belleville, L. Soussan
Institut Européen des Membranes, IEM – UMR 5635, Univ. Montpellier, ENSCM, CNRS, Montpellier, France

Abstract:
Methanol (MeOH) is a platform molecule widely used in the chemical industry (plastics, paints, fuels, etc.). The current industrial process for producing methanol uses methane (CH_4) as raw material but the process is energy-consuming and releases significant amounts of CO_2.

Non-pathogenic methanotrophic bacteria naturally synthetize Methane MonoOxygenase (MMO) enzymes that oxidize selectively CH_4 to MeOH in physiological conditions. Implementing these bacteria for CH_4 hydroxylation (*i.e.* CH_4 conversion into MeOH) constitutes a promising biotechnological alternative to the current industrial process. MeOH accumulation needs additions of MeOH-oxidating enzymes inhibitors and formate as an electron donor [1]. Efficient inhibition is ensured with the synergic action of NaCl and EDTA. The global balance of the reaction is given in Equation 1: $CH_4 + O_2 + HCOO^- + H^+ \rightarrow CH_3OH + CO_2 + H_2O$.

The CO_2 produced is then mainly assimilated into biomass [2]. This work confirmed the feasibility of the bioprocess and ^{13}C-assays demonstrated that the MeOH produced was exocellular and arose from CH_4 only.

However, the MeOH production stops after around 20 h reaction (Fig. 1). This result is consistent with the literature reporting the stop of MeOH accumulation which is regardless of the bioreactor design or operating conditions used [2].

The production stop could result from a moderate alkalization of the reaction mixture or from a limitation in gaseous subtrates, nutrients and electron donor. The MeOH produced may also induce potential enzymatic inhibition and cell toxicity. Other explanations are linked to inhibitors since NaCl could cause osmotic stress and EDTA could chelate MMO metallic cofactors, which could be then lacking.

All these hypotheses were investigated. Growth tests and reaction assays were carried out in various conditions in order to estimate potential cell toxicity or enzyme inhibition. Enrichment in MMO metallic cofactors in view to extend MeOH production time was done.

Finally it appeared that EDTA action on cell integrity was likely to be the major cause of the reaction stop. Consequently, cell regeneration was tested and regenerated cells were demonstrated to be able to produce again MeOH at similar productivity than obtained over the first 20 h reaction (Fig. 1).

Operating reaction and regeneration reactors in parallel can be a way to enhance MeOH production by *M. trichosporium* OB3b. As a perspective, alternative inhibitors to EDTA will be investigated.

Keywords: Methane, *Methylosinus trichosporium* OB3b, bio-hydroxylation, methanol production, bioprocess limitations, cell regeneration

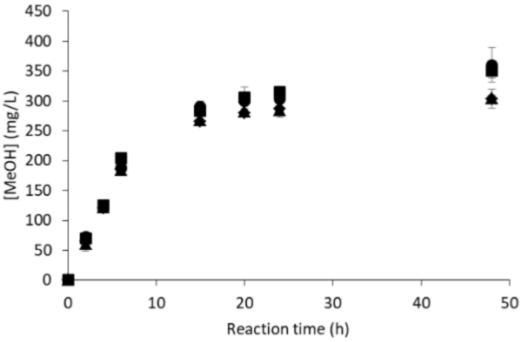

Figure 1: MeOH production kinetics by *Methylosinus trichosporium* OB3b in batch mode (4 independant replicates).

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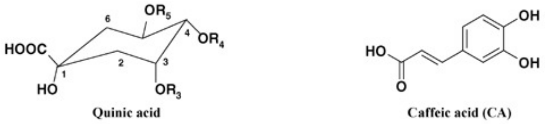
Phenolic content of orange sweet potato flour influenced by ultrasound pretreatment, cold storage, and drying technologies.

A. Gomez-Cisneros, M. Calderon-Oliver, L. Santos-Zea, A. Escalante-Alburto
Department of Sciences and Engineering, Tecnologico de Monterrey, Nuevo León, Mexico

Abstract:

Sweet potatoes are nutritious and contain bioactive compounds such as phenolics, which are beneficial to human health. However, their consumption is declining in Mexican society as they are not a popular food, and their presence on the market is limited as sweet foods. To expand the market, increase the consumption of sweet potatoes, and take advantage of their potential, this study aimed to develop a method to obtain sweet potato flour (SPF) without reducing bioactive compounds, particularly phenolics. The effects of ultrasound (US) pretreatment (40 kHz, 10 min at 25°C), storage time after pretreatment (0–96 h), and drying method (dehydration and freeze-drying) were evaluated to determine which method had the least impact on the total phenolic content (TPC) of the obtained flour. As an immediate response to US pretreatment, TPC decreased in SPFs. US-treated sweet potatoes showed increased phenolic content after 72 hours of storage, with the highest level almost doubling. In addition, chromatographic analysis was performed to identify the phenolic types present in SPF, where chlorogenic acid and its derivatives were identified. Ultrasound pre-treatment and storage duration resulted in a significant interaction ($p<0.05$) that influenced TPC in SPFs, whereas the drying method was not a significant factor. These results suggest that ultrasound pretreatment and cold storage at 4°C can increase the phenolic content of sweet potato flour. This method can be utilized to generate flours with a higher concentration of phenolics, which could be used to develop functional foods.



Name and abbreviation		R_3	R_4	R_5
Chlorogenic acid (ChA):				
5-*O*-caffeoylquinic acid	(ChA)	H	H	caffeoyl
Isochlorogenic acids:				
4, 5-di-*O*-caffeoylquinic acid	(4,5-diCQA)	H	caffeoyl	caffeoyl
3, 5-di-*O*-caffeoylquinic acid	(3,5-diCQA)	caffeoyl	H	caffeoyl
3, 4-di-*O*-caffeoylquinic acid	(3,4-diCQA)	caffeoyl	caffeoyl	H
3, 4, 5-tri-*O*-caffeoylquinic acid	(3,4,5-triCQA)	caffeoyl	caffeoyl	caffeoyl

Figure 1: Some of the bioactive compounds in the sweet potato are the chlorogenic acid and the isochlorogenic acids (Truong, 2007).

Keywords: sweet potato flour, ultrasound, dehydration, freeze-drying, phenolics, storage.

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Nanotech France/ GAMS/ Biotech France 2024 Joint Plenary session II

Materials for Eco-Design Strategies for an Innovative Industry

R. Martins, S. Nandy, P. Barquinha, L. Pereira, T. Pinheiro, H. Almeida, R. Igreja, E. Carlos, E. Fortunato,
Materials Science Department, CENIMAT|I3N and CEMOP/UNINOVA, Faculty of Sciences and Technology, NOVA University Lisbon, 2829-516 Caparica, Portugal.

Abstract

With the growing smartness in electronic manufacturing worldwide, printed electronics technologies draw tremendous attention because of their ability to overcome the limitation of traditional high-cost manufacturing approach which is mostly based on rigid silicon substrate. In these issues, printing technology can be used to fabricate devices on various kind of flexible substrate such as paper, textile, bendable polymers even on human skin. On the other side, printed electronics has a great potential to offer biodegradable and recyclable solutions, by choosing low-cost substrate for printing devices, that may be recycled and/or naturally degraded in nature. This is a way forward to minimize the electronic waste (e-waste) caused by the ever- increasing number of disposable electronic devices. Relevantly, "printing electronics on paper" technology is rapidly developing in both research and electronic industry fields during the last decade. [1] Generally, printing processes involve a sequence of tasks, starting with the selection of functional materials along with the envisioned functionality, moving to the formulation of inks, and then the selection of a suitable substrate. Printing technique depending on the ink's properties and intended features for the printed film. There are several printing technologies, that are being used in research and industrial sectors from lab-scale to large-scale application, such as screen printing, flexographic (or flexo-) printing, gravure printing, gravure-offset printing, and roll-to-roll (R2R) printing. A long list of functional materials, from conductive polymers, ionic liquids, and carbon nanostructures to metallic nanoparticles, and metal oxide nanostructures with conductive, semiconducting, or dielectric properties, can be used to formulate these inks. [2-4] The development of stable, cost-effective, non-toxic, and eco-friendly printable inks with desired printability is crucial to deposit and pattern these materials onto a substrate to enable the production of a new class of devices for electronics and energy purposes that are extremely lightweight, affordable, readily customizable, thin, flexible, and recyclable.

Keywords: Flexible electronics, responsible electronics; sustainable electronics

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Applications of direct-write nanoscale materials in Nanotechnology

José María De Teresa [1*]
[1] Instituto de Nanociencia y Materiales de Aragón (INMA), CSIC-Universidad de Zaragoza,
Zaragoza, Spain

Abstract:

In this keynote talk, I will review the recent results published by the Nanomidas group at INMA in the topic of applications of direct-write nanoscale materials. The direct-write techniques used in our group rely on focused electron and ion beams. Whereas focused electron beams are produced in a Scanning Electron Microscope (SEM) and are mainly used for imaging or for electron beam lithography, the Focused Ion beam (FIB) is mostly popular for nanopatterning via the local removal of material. Interestingly, if one combines focused electron or ion beams with a precursor gas, a local deposit can be grown and the techniques are respectively named Focused Electron Beam induced Deposition (FEBID) and Focused Ion Beam Induced Deposition (FIBID). By means of FEBID/FIBID, one can grow ultra-sharp tips on cantilevers, with applications in Atomic Force Microscopy (AFM) and Magnetic Force Microscopy (MFM). For example, the $W(CO)_6$ precursor allows the growth of W-based tips by FEBID and FIBID, of great interest to study the dynamics of biomolecules by AFM [1]. Similarly, the $Fe_2(CO)_9$ precursor allows the growth of Fe-based MFM tips by FEBID, of great interest to study magnetic films [2]. Such metal-based tips are very robust and start to be commercialized by AFM/MFM companies. The use of the $W(CO)_6$ precursor in FIBID is also relevant for quantum technologies, given that the grown deposits are superconducting below $T_C \sim 5$ K and can be used to create Josephson junctions and nanoSQUIDs, as shown by our group [3]. In a different strategy, the FIB can be used to irradiate spin-coated organometallic films, which become decomposed into metal-rich micro- or nano-structures without the need of resists (as typically required in standard lithography techniques). We have made experiments using spin-coated PdAc films that indicate that very low Ga^+ irradiation doses produce Pd-rich highly-conductive structures, of application for electrical contacts and allowing fabrication with a high lateral resolution (~ 40 nm) [4].

Keywords: Focused ion beam, FEBID, FIBID, electrical contacts, AFM tips, MFM tips, Josephson junctions, nanoSQUIDs.

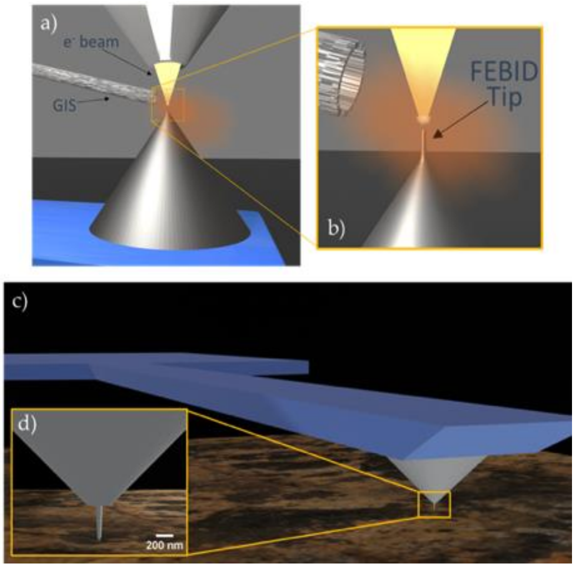

Figure 1: Figure illustrating the growth of ultra-sharp tips by focused electron beam induced deposition (FEBID), for applications in AFM and MFM. Figure extracted from reference 2.

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The toxicology of inhaled nanoparticles and examples of risk assessment and regulation

Ulla Vogel [1]
[1] National Research Centre for the Working Environment, Copenhagen, Denmark

Abstract:

At the turn of the century, nanotechnology was the big innovation potential. Now, more than two decades later, there is scientific consensus that particle size is important and that nano-sized particles are more hazardous to inhale than larger particles with the same chemical composition. This is especially true for insoluble particles. In addition, shape and solubility are important predictors of toxicity.

Inhalation of particles is linked to increased risk of cancer, cardiovascular disease, fibrosis and COPD and Adverse Outcome Pathways to describe the causal relationships have been proposed .

Following inhalation, alveolar deposition is determined by particle size distribution. The alveolar deposition leads to low clearance rates, resulting in high lung burden. High- aspect-ratio nanomaterials have very low clearance rates, similar to asbestos.

Particle presence in the lung induces inflammation and acute phase response, which are proportional to the deposited surface area. Acute phase response is a risk factor for cardiovascular disease, and inflammation is linked to fibrosis, cancer and COPD. Other putative mechanisms-of-action for carcinogenicity include frustrated phagocytosis of high-aspect-nanomaterials, and particle-induced generation of reactive oxygen species and oxidative stress.

Examples of health-based occupational exposure limits will be presented for the process-generated nanoparticle diesel engine exhaust, for insoluble nanoparticles such as carbon black and titanium dioxide, for the asbestos-like carbon nanotubes and for the soluble ZnO. In addition, the pathway to societal impact of the research is described.

Keywords: nanoparticle, ultrafine particle, cancer, cardiovascular disease, fibrosis, risk assessment, occupational exposure limit

Lung fate and biotransformation of exfoliated MoS_2

Alberto Bianco
CNRS, Immunology, Immunopathology and Therapeutic Chemistry, UPR 3572, University of Strasbourg, ISIS, 67000 Strasbourg, France

Abstract:

Among the different bidimansional nanomaterials, MoS_2 have received tremendous attention in many fields, including electronics, composites and nanomedicine.[1,2] We have recently applied a combined approach to follow the fate and biotransformation of MoS_2 nanosheets and their impact on lung inflammation status over one month after a single inhalation dose in mice. The analysis of the immune cells, the alveolar macrophages, the extracellular vesicles, and the cytokine profile showed that MoS_2 nanosheets can induce an initial phase of pulmonary inflammation that is rapidly resolved despite the persistence of various biotransformed molybdenum-containing nanostructures in alveolar macrophages and extracellular vesicles up to one month (Figure 1). Using in situ liquid phase transmission electron microscopy, we evidenced the dynamics of MoS_2 nanosheet transformation triggered by reactive oxygen species. Three main alteration mechanisms were observed: 1) scrolling of the dispersed sheets leading to the formation of nanoscrolls and folded patches, 2) etching releasing soluble MoO_4^-, and 3) oxidation generating oxidized sheet fragments. Extracellular vesicles were also identified as a potential shuttle of MoS_2 nanostructures and their degradation products and more importantly as mediators of inflammation resolution.[3]

Keywords: Bidimensional materials, graphene, biomedical applications, toxicity, biodegradation, carrier, lung, inhalation, extracellular vesicles, transmission electron microscopy.

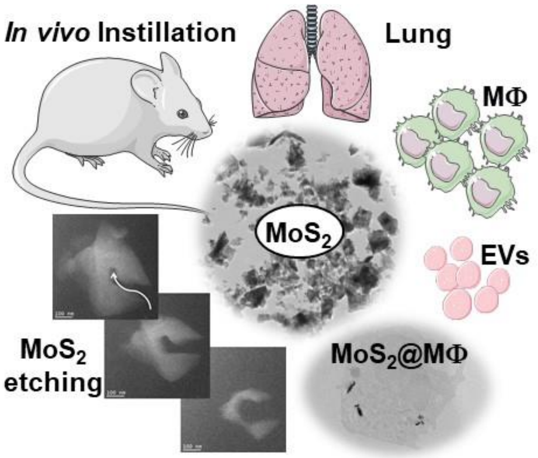

Figure 1: Degradation, fate and impact on lungs of MoS_2 nanosheets.

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Blood-brain barrier-on-a-chip as a suitable platform to evaluate gold nanoparticles against Alzheimer's disease.

Andreas Tapia-Arellano[1,2,3,4]*, Sujey Palma-Florez[1,5], Pablo Cabrera[4], Elizabeth Cortés-Adasme[4], Karen Bolaños[4], Rebeca Aldunate[6], Natalia Hasan[2,3], Marcelo J. Kogan[4], Josep Samitier[1,7,8], Anna Lagunas[1,7], Mònica Mir[1,7,8].

[1]Nanobioengineering group, Institute for Bioengineering of Catalonia (IBEC) Barcelona Institute of Science and Technology (BIST), 12 Baldiri Reixac 15-21, Barcelona 08028, Spain. [2]Instituto Universitario de Investigación y Desarrollo Tecnológico (IDT), Universidad Tecnológica Metropolitana, Chile. [3]Millenium Nucleus in NanoBioPhysics. [4]Facultad de Cs. Qcas. y Farmacéuticas, Universidad de Chile, Chile. [5]Department of Electronics and Biomedical engineering, University of Barcelona, Martí i Franquès 1, 08028 Barcelona, Spain. [6]Facultad de Ciencias, Universidad Santo Tomás, Chile. [7]Networking Biomedical Research Center in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), Madrid, Spain. [8]Department of Electronics and Biomedical engineering, University of Barcelona, Martí i Franquès 1, 08028 Barcelona, Spain.

*atapia@ibecbarcelona.eu

Abstract:

Alzheimer's disease (AD) is one of the most important neurodegenerative diseases and the most common dementia. One of the hallmarks is the aggregation process of amyloid-β peptide (Aβ), responsible for neuron death both in vitro and in vivo studies [1], and the main strategy to be inhibited. However, the current strategies have failed because they cannot either reach an adequate concentration in the brain or cross the blood-brain barrier (BBB).

In this regard, Nanobiotechnology has acquired great relevance where efforts have focused on the detection, diagnosis, and therapy of diseases. Gold nanoparticles (GNP) have stood out in this area for being stable, biocompatible, and easy to synthesize. GNP possess attractive properties and can be functionalized with different kinds of molecules to be used in drug delivery and targeting and have also being demonstrated to cross biological membranes such as the BBB [2].

However, the effect of GNP on the BBB is poorly understood in a biological context. For this reason, it is mandatory to develop an approach to evaluate them in a reproducible, cheaper, and animal-free model, such as organ-on-a-chip (OoC) technology that allows mimicking biological conditions [3]. In this work, GNP were analyzed into a BBB-on-a-chip (BBB-oC) model composed by a 3D co-culture of human endothelial, astrocytes, and pericytes cells. Cytotoxicity and permeability of GNP were evaluated in this platform. Thus, our BBB-oC system emerges as a useful tool to assess the permeability of potential nanosystems in a cheaper and high-throughput manner for new treatment against AD.

Keywords: Alzheimer's disease, protein misfolding, gold nanoparticles, blood-brain barrier, organ-on-a-chip.

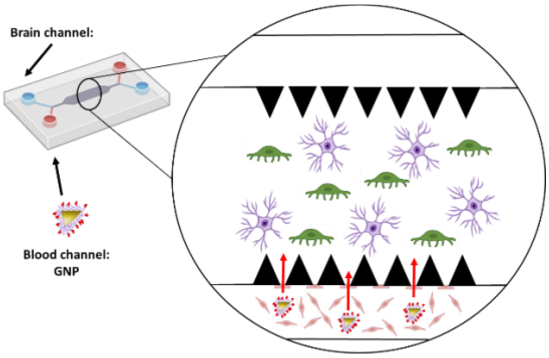

Figure 1: Blood-brain barrier-on-a-chip illustrating the main parts of the platform. The blood channel contains the endothelial barrier, while the brain channel contains the pericytes and astrocytes cells. Gold nanoparticles were injected into the blood channel to evaluate their permeability into the brain channel. Also, the citotocity effect of gold nanoparticle was analyzed by live/dead kit on the different cell lines.

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Exploiting New Strategies to Deliver an Old Drug

B. Stella [1]
[1] Department of Drug Science and Technology, University of Turin, Turin, Italy

Abstract:

Drug repurposing, a strategy for identifying new applications for approved or investigational drugs that are outside the scope of the original medical indication, has promising expectations regarding efficacy, safety, cost and translation to the clinical setting: indeed, repurposed drugs have already been studied in preclinical models and humans for safety assessments. Moreover, in many cases the formulation aspects are already developed. In this context, pentamidine (PTM), a diamine composed of two 4-alkoxy phenylamidine groups linked by a five-carbon methylene linker (Figure 1), is an old drug that was first used to treat African trypanosomiasis in 1937 and leishmaniasis in 1940 before it was registered as PTM mesylate in 1950. Now marketed in the form of two salts (isethionate and mesylate), it is administered *via* the intravenous and intramuscular routes, and *via* inhalation, for treating systemic and cutaneous parasitic diseases, such as trypanosomiasis, leishmaniasis, *Pneumocystis pneumonia* (PCP) and to prevent PCP in high-risk, HIV-infected patients [1].

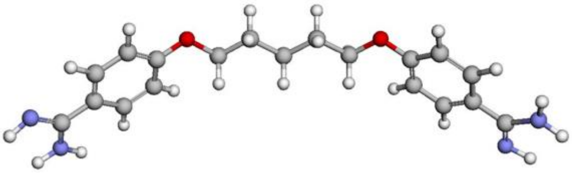

Figure 1: Representation of PTM structure (carbon atoms are gray, oxygen red, nitrogen light blue, hydrogen white).

Thanks to its wide use in clinics, PTM is the most studied member of the diamidines to be repurposed for other therapeutic strategies. In this context, several studies have shown PTM *in vitro* and *in vivo* activity on a wide range of tumor types, including breast, melanoma, prostate, leukemia, and renal cancers, highlighting a multifactorial mechanism [2]. Furthermore, PTM has been investigated as an experimental muscular distrophy treatment; in particular, myotonic dystrophy type I results in the dystrophia myotonica protein kinase (DMPK) gene mutation, which leads to the amplification of the (CTG)n triplets. Furthermore, the transcription of expanded (CUG)n forms aggregates of hairpin structures in the nucleus, namely nuclear foci, responsible for the sequestration of the splicing factor muscle-blind-like (MBNL) protein family and the consequent myotonia and muscle weakness. Recent *in vitro* and *in vivo* studies demonstrated that PTM associates with the expanded triplets, preventing MBNL1 sequestration, decreasing the formation of nuclear foci and reducing myotonia in experimental models [3].

Although all these studies open up interesting perspectives for the use of PTM as an antineoplastic and anti dystrophia myotonica drug, its assumption is accompanied by several side effects, such as hypo- and hyperglycemia, cardiotoxicity, pancreatic complications and nephrotoxicity [2].

To overcome PTM therapy drawbacks while enhancing its bioavailability, different nanosystems (polymeric, lipidic and inorganic) for different therapies have been proposed [2]. In this field, our efforts have been focused on the association of PTM to different nanocarries, from inorganic, polymer and lipid particles till to hybrid nanosystemes, taking advantage of the peculiar molecular structure of PTM; these studies have been devoted to improve drug loading, biocompatibility and efficacy and, at the same time, to decrease PTM side effects [4-8]. To further improve the therapy outcome, we have also associated these nanocarriers to selective ligands able to recognize specific receptors on the surface of target cells, thus obtaining a indirect or direct drug active targeting [6-8]. To illustrate our approach, several examples of PTM delivery strategies will be illustrated.

Keywords: drug repurposing, pentamidine, nanoparticles, squalene, liposomes, active targeting.

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NanoMatEn / GAMS Joint Session II.B: Materials and Nanomaterials for Energy / Nanoelectronics / Nanophotonics

From Lab to Pilot: VTT's Advances in Sustainable Cellulose Film and Coating Technologies

V. Kumar, V. Kunnari, H. Ahadian, A. Khakalo, A. Jaiswal, P. Ahokas, A. Sonker, A.Yamamoto
VTT Technical Research Centre, Finland

Abstract:

Reducing the usage of fossil-based raw materials and growing environmental concerns are driving forces behind VTT research to discover alternatives for plastics in various applications. Moreover, legislative measures have been put in place to limit the use of plastic. These factors have encouraged us to develop of innovative technologies for producing sustainable bio-based films and coatings. Transparent cellulose films and cellulose-based coatings have demonstrated high potential to address these issues.

VTT has developed a range of innovative films made from cellulose, including fibrillated cellulose, dissolved cellulose, novel thermoplastic cellulose, and combinations of these materials. These films have shown great potential for replacing plastics in packaging, but their applications extend far beyond. They can be used in construction to create more sustainable housing, in the creation of porous substrates for filtration and sorption, as separators in Li-ion batteries and supercapacitors, in the production of flexible printed electronics, and as functional films for diagnostic and medical applications.

In addition to laboratory research, VTT has set up a pilot facility at its Bioruukki piloting centre in Espoo, Finland, to further develop the cellulose films and coatings technology and demonstrate its feasibility and scalability.

SUTCO is a modular surface treatment pilot line used to innovate sustainable bio-based coatings for beverage, food, or personal hygiene packaging. It can also be utilized to find solutions for various industries such as paper, textile, chemical, medical and electronic industries. Different technologies, such as die, foam, dispersion, and spray coatings, can be trialled using the SUTCO line.

VTT CelluloseFilms is a versatile pilot line for producing regenerated cellulose films. The technology to dissolve and regenerate cellulose enables chemical recycling and does not require the use of harmful chemicals. A wide range of raw materials, from dissolving pulp to alternative pulps and recycled cellulose, can be used in the process. Films have shown excellent barrier and mechanical properties. In addition, they can be functionalized thus offering new possibilities for making water-resistant and compostable cellulose films. With the use of this pilot line, various substrates, i.e carton boards can be laminated with regenerated cellulose or impregnated with different chemicals.

Keywords: Regenerated cellulose films, Nanocellulose coating, Plastics alternatives, Sustainability, Modular pilot lines

An innovative strategy to fabricate wrinkled silver-based nanoporous material combining plasma-based technique and dealloying process

Robin Dantinne [1], Adrien Chauvin [1], Suyog Asaram RAUT [1], Philippe Leclere [2], Claude Poleunis [3], Arnaud Delcorte [3], Rony Snyders [1,4] and Damien Thiry [1]
[1] Chimie des Interactions Plasma-Surface (ChIPS), CIRMAP, University of Mons, Mons, Belgium.
[2] Laboratory for Physics of Nanomaterials and Energy (LPNE), CIRMAP, University of Mons, Mons, Belgium
[3] Institute of Condensed Matter and Nanosciences (IMCN), Université catholique de Louvain (UCL), Louvain-la-Neuve, Belgium
[4] Materia Nova Research Center, Parc Initialis, Mons, Belgium

Abstract:

Due to their tremendous potential in various domains such as optics and catalysis, nanoporous silver-based materials have been the subject of multiple studies triggering the development of versatile synthesis methods with a limited economical and environmental cost. Although scarcely studied in this context, plasma-based deposition processes are a promising approach due to their high flexibility, the absence of solvent and the industrial scalability of the technique. In this context, in this work, an innovative strategy is developed to fabricate wrinkled silver-based nanoporous material by combining plasma-based techniques and dealloying processes.

At first, a highly viscous allylalcohol plasma polymer film (PPF) was deposited. Although these coatings are usually reported to behave as hard elastic films (with a Young Modulus of about 5 GPa), we have recently reported the availability to modulate in a wide range the glass transition temperature of the polymeric network (i.e. from -10°C to 92°C) enabling the fabrication of mechanically responsive PPF.[1]

In a second step, a top Ag-Al alloy thin film (from 50 to 150 nm) is deposited on this compliant layer by another plasma-based method, namely the magnetron co-sputtering technique, using aluminium and silver targets. The resulting bilayer system spontaneously gives rise to a morphological reorganization resulting in the formation of a wrinkled surface. The dimensions of the wrinkles can be precisely modulated (i.e. from 300 to 500 nm) by altering the thickness of the coating involved in the bilayer system.

Exposition of the wrinkled surface to HCl vapors leads to the dealloying process, i.e. the selective removal of the least noble element (here aluminium), resulting in the formation of a nanoporous silver-based structure. The size of the nanopores can be finely tuned (i.e. from 50 to 400 nm) by the modulation of the dealloying time. Interestingly, the wrinkled original shape is maintained after the dealloying process, paving the way for the fabrication of tailor-made bimodal nanostructured silver-based material.

Finally, the potential of those surfaces as SERS substrate for rhodamine has been demonstrated, promising for practical applications including the detection of low concentrations of pollutants or biomolecules.

Keywords: Plasma-based processes, nanoporosity, bimodal nanostructuration, plasma polymerization, PECVD, magnetron sputtering, dealloying, wrinkling.

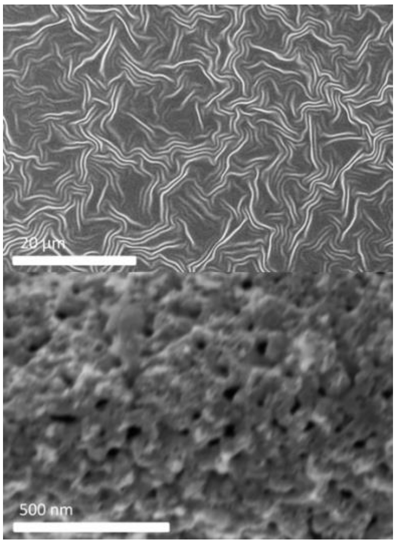

Figure 1: SEM images of a wrinkled silver-based nanoporous surfaces fabricated by combining plasma-based and dealloying techniques.

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Development of Fluorine-Free Superhydrophobic Surfaces combining Plasma Polymerization and the wrinkling approach

Suyog Asaram Raut[1], Robin Dantinne[1], Rony Snyders,[1,2] and Damien Thiry[1*]
[1]Chimie des Interactions Plasma-Surface (ChIPS), CIRMAP, University of Mons, Mons, Belgium
[2]Materia Nova Research Center, Parc Initialis, Mons, Belgium

Abstract:

This research focuses on creating robust superhydrophobic surfaces without fluorine-based compounds[1], addressing environmental concerns, and promoting sustainable alternatives. The proposed methodology is based on the spontaneous wrinkling phenomenon in a bilayer[2,3] system formed by a mechanically responsive bottom plasma polymer layer and a top Al/Ag alloy-based thin film (see Figure 1, for example). The synergy between these techniques aims to create a fluorine-free superhydrophobic layer characterized by low surface energy and micro/nano-scale roughness, mimicking natural surfaces with exceptional water-repellent properties. The study systematically optimizes process parameters to achieve optimal superhydrophobicity and comprehensive characterization using water contact angle (WCA) measurements, scanning electron microscopy, and atomic force microscopy.

It has been shown that the WCA can be adjusted from 120° to 145° by tuning the wrinkles' nano-architecture governed by the coatings' thickness and the atomic silver content. For optimized conditions, the wrinkled material is used as a pattern for further deposition of an additional hexamethyldisiloxane plasma polymer layer homogeneous covering the surface relief, enabling it to reach superhydrophobicity (i.e., WCA > 160°C). These developed fluorine-free superhydrophobic surfaces hold promise for applications in diverse fields, such as self-cleaning materials, anti-icing coatings, and microfluidic devices, contributing to advancing eco-friendly and sustainable surface engineering technologies.

Keywords: Plasma Polymer Films, Fluorine Free Superhydrophobic Surface, Magnetron Sputtering, PECVD

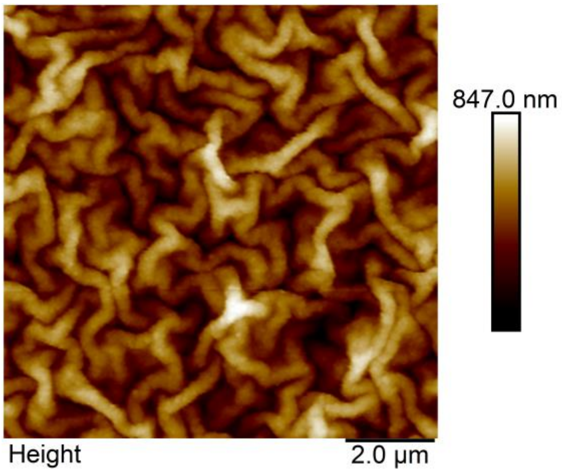

Figure 1: AFM image of Ag-Al alloy-based thin film deposited over the plasma polymer layer.

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Unraveling the Potential of Non-Thermal Plasma in the Synthesis and Surface Tailoring of Silicon Nanoparticles

F. Matejka [1,2,*], J. Kopenec [2], P. Galar [1,2], T. Popelar [2], K. Kusova [2]
[1] Department of Physics, University of Chemistry and Technology, Prague, Czech Republic
[2] Institute of Physics, Czech Academy of Science, Prague, Czech Republic

Abstract:

Silicon nanoparticles (SiNPs) are a class of nanoparticles with a wide range of application prospects due to their inherently low toxicity. They can be obtained by a variety of processes. On of them is low-pressure non-thermal plasma (NTP) synthesis, which provides both larger SiNPs (diameter from 54 to 20 nm) and quantum-confined SiNPs (sub-10-nm particles, SiQDs). Small SiNPs exhibit high intensity of photoluminescence (PL), accompanied by size-tunable PL maxima.[1] Till this day, this method was unable to produce SiNPs with diameters larger than 50 nm. In this work, we extend the NTP setup for the fabrication of SiNPs with a diameter larger than 80 nm, which can find their use, for example, in the battery industry.

Another limit of the low-pressure NTP system is the production of SiNPs with a highly reactive hydrogen terminated surface, which is prone to fast oxidization. Therefore, for all of the SiQDs sizes, proper surface termination is needed for tailoring the PL properties (intensity and position), reactivity and affinity to a broad variety of environmnets (from organic to inorganic), see the Illustration in Figure 1.[2,3] To address this issue, we present a novel method using NTP for the generation of a highly reactive environemt, inducing fast surface reactions. With this method, we are able to terminate the surface of SiNPs within one hour in a broad range of liquids, ranging from water to organic molecules with aliphatic chains or aromatic structures. Therefore, we can provide on-demand tailoring of optical properties and affinity and size of SiNPs by NTP.

Keywords: silicon quantum dots (SiQDs), synthesis, silicon nanoparticles (SiNPs), surface tailoring, photoluminescence, low-pressure plasma, non-thermal plasma (NTP), plasma-activated liquids (PAL)

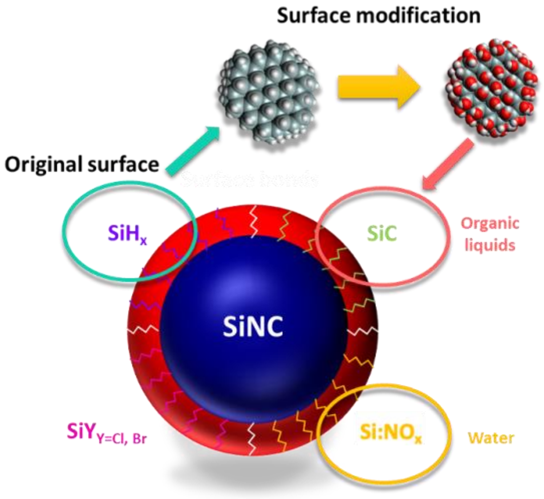

Figure 1: Illustration of the crucial process of surface tailoring of the silicon quantum dots, which can be provided by non-thermal plasma systems

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Sequenced plasma electrolytic oxidation of aluminium alloys: a tool to control the coating porosity

L. Magniez[1], S. Fontana[1], J. Martin[1, 2], C. Hérold[1], G. Henrion[1, 2]

[1] Université de Lorraine – CNRS – Institut Jean Lamour, Campus ARTEM, F5400 NANCY, France
[2] Université de Lorraine, LabEx DAMAS, F57000 METZ, France

Abstract:

Despite the progress made over the last 20 years in understanding the PEO process, certain aspects are still poorly understood and there are still obstacles to overcome to master this surface treatment process. This especially holds for what concerns the deep incorporation of nanoparticles into the growing PEO coatings. Indeed, many works report on the incorporation of various kinds of particles [1], but it appears that particles dispersed in the electrolyte mainly incorporate in the outer porous sublayer and no particles are observed in the dense inner sublayer [2, 3].

Operating PEO with multiple successive sequences - that is by varying the current waveform during the process - can be a way to improve in depth incorporation of particles into the dense inner layer. Indeed, tuning the current waveform with an anodic to cathodic charge quantity ratio (r) greater than 1 corresponds to the so-called arc regime, which results in highly porous layer. Conversely, it is well known that the soft regime (r < 1) leads to dense layer with a light porosity in the outermost sublayer. Therefore, a suitable adjustment of such sequences could help trapping the particles in the porous layer that will then be densified along with the second sequence. The present communiction deals with the study of a sequenced PEO processing of aluminium alloy with first a pulsed unipolar anodic current (r = ∞) followed by a second sequence using a pulsed bipolar current under the soft regime conditions (r = 0.89). Analyses and characterizations of the grown PEO coatings along the processing time clearly show the evolution of the coating morphology that exhibits a pancake structure with large pores at the coating – metal interface at the end of the first sequence. That structure then progressively changes for a dense coating during the second sequence of current (Fig. 1). Meanwhile, the variations of the anodic voltage amplitude along with the processing time help predicting the changes in the coating microstructure.

Keywords: Aluminium, plasma electrolytic oxidation, bipolar current pulse, nanoparticles.

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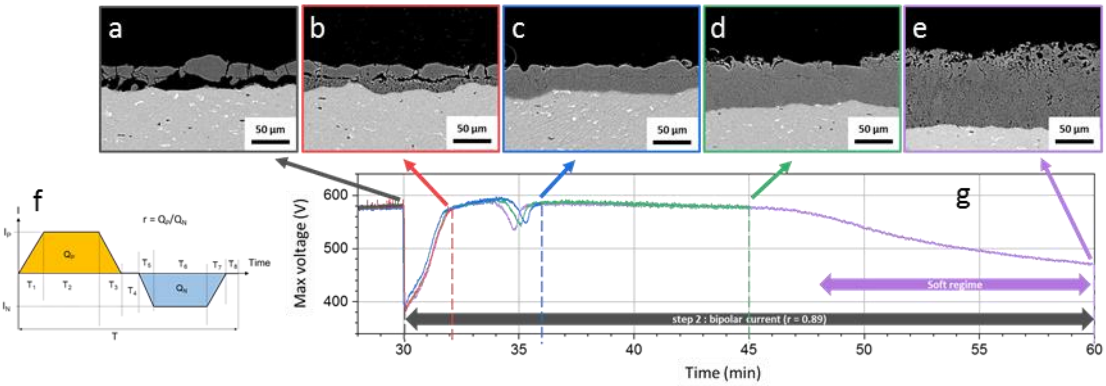

Figure 1. (a-e) SEM cross section views of alumina coating at different times of a two-sequences PEO processing of aluminium. Each sequence lasts 30 min. First sequence: r = □; second sequence: r = 0.89. (f) Schematic of the current waveform. (g) Time variation of the anodic voltage amplitude during the process.

Investigation the effect of applied voltage on the modification of surface roughness of materials after plasma electrolytic polishing

Nguyen Truong Son[1, 2], L. Magniez[1], J. Martin[1,3], Gérard Henrion[1,3,] F. Girard[2]
[1] Université de Lorraine – CNRS – Institut Jean Lamour, Campus ARTEM, F5400 NANCY, France
[2] Sermatec, 159 rue Geogres Mélìes, F41350 VINEUIL, France
[3] Université de Lorraine, LabEx DAMAS, F57000 METZ, France

Abstract:

Stainless steel and similar metal alloys are indispensable in various industries owing to their exceptional durability and resistance to corrosion, playing pivotal roles in automotive, medical, and electrical applications due to these qualities [1]. Surface treatments encompass a range of methods such as sandblasting, chemical cleaning, and electropolishing (EP) techniques, all aimed at refining surfaces by eradicating imperfections, thereby enhancing their appearance and functionality [2, 3]. However, traditional surface treatment methods face constraints such as limitations on size, potential safety hazards from handling fragments, and problem of environmental pollution. In response, the development of Plasma Electrolytic Polishing (PEP) has marked a significant advancement. PEP stands out as an eco-friendly, highly efficient alternative that utilizes non-toxic electrolytes compared to its predecessors [4, 5]. This innovative approach has promise and interest, particularly for its ability to offer a balance between efficacy and environmental consciousness.

The present study focuses on the effect of applied voltage on the PeP of stainless steel (304, 316) employing an environmentally friendly electrolyte ($NH_4(SO_4)_2$). It is shown that PeP is efficient whatever the applied voltage in the range 100 – 500 V. However, the best efficiency is obtained for an applied voltage of 200 – 300 V (Figure 1). These results will be discussed based on the plasma polishing mechanisms.

Keywords: surface treatment, plasma polishing, plasma electrolysis.

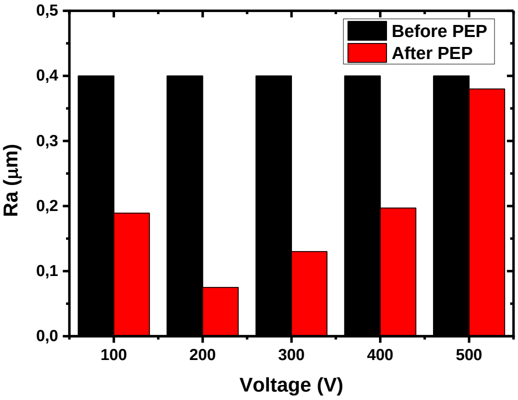

Figure 1: Influence of the applied voltage on the surface roughness after plasma electrolyte polishing in $NH_4(SO)_4$. Processing time was 2 minutes for each sample.

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Aerosol Assisted Chemical Vapor Deposition of Copper Sulfide films with sensitivity to NO_2

Houyem Trabelsi [1,2], Isabel Gràcia [1], Khaled Alouani [2], Stella Vallejos [1]
[1] Institute of Microelectronics of Barcelona (IMB-CNM, CSIC), Barcelona, Spain
[2]Department of chemistry, University of Tunis El Manar, Faculty of Science, Tunis, Tunisia

Abstract:

Metal chalcogenides (MC), such as copper sulfide (Cu_2S), have attracted significant interest among researchers due to their use in solar cells, gas sensing technology, and energy storage devices, to cite few [1]. Previous studies have explored the deposition of MC thin films employing physical or chemical methods. These approaches typically utilize a variety of precursors. However, single source precursor (SSPs) complexes offer advantages due to their simplified pathways for the MC synthesis [2]. Hence, this works reports the synthesis of copper sulfide thin films (Cu_2S) from an experimental SSPs copper complex based on organochalcogenophosphorus ligand. The films were processes via Aerosol Assisted Chemical Vapor Deposition (AACVD) at 400 ºC and 450 ºC using the system reported early [3]. SEM of the films demonstrated granular- or sheet-like morphology when deposited at 400 ºC or 450 ºC, respectively (Figure 1). EDX indicated a Cu/S ratio of 2 (anal. calc. for Cu_2S: Cu 39.9 and S 20.1 at%; found Cu 41.3 and S 20.6 at%). XRD results shows the films are crystalline and consistent with a tetragonal phase of Cu_2S (ICDD card nº 04-024-2237). Light activated test upon NO_2 showed better responses for the Cu_2S deposited at 450 ºC as compared to those deposited at 400 ºC (Figure 2). These results and other properties of the film and the SSP complex will be discussed at the conference.

Keywords: Copper Sulfide; Single Source Precursor, AACVD, Gas Sensors.

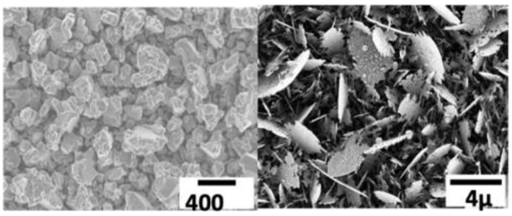

Figure 1: SEM images of Cu_2S thin films deposited at 400 ºC (left) and 450ºC (right) on Si substrates.

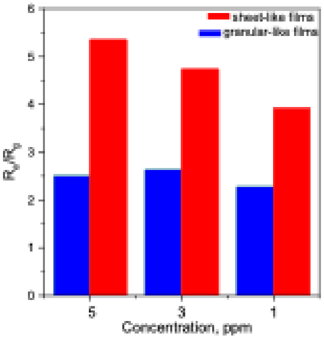

Figure 2: Light activated response of the films to different concentration of NO_2.

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Modulation of Spin and Charge Currents Through Functionalized 2D Diamond and Few-layer Boron Nitride Devices

E. E. de Moraes [1],A. A. Pinto [2], R. J. C. Batista [2], A. B. de Oliveira [2], H. Chacham [3]
[1] Department of Physics, Federal University of Bahia, Salvador,Brazil
[2] Department of Physics, Federal University of Ouro Preto, Ouro Preto, Brazil
[3] Department of Physics, Federal University of Minas Grais, Belo Horizonte,Brazil

Abstract:

A recent development in the field of 2D materials is the structural transformation of few-layer graphene and few-layer hexagonal boron nitride (h-BN) into sp3-bonded few-layer diamond and c-BN, respectively, through the application of pressure at room temperature.[1-6] In experiments under humid conditions, a proposed mechanism[1,3], based on the results of ab initio calculations, is that the $sp^2 \rightarrow sp^3$ transition is facilitated by a combination of applied pressure and the functionalization by OH or H radicals. In this study, we explore the potential of functionalized two-dimensional (2D) diamond[7] and boron nitride[8] for spin-dependent electronic devices using first-principles calculations. For 2D diamond, we investigate functionalizations with either hydroxyl (−OH) or fluorine (−F) groups. In the case of an isolated layer, we observe that the quantity and distribution of (−OH) or (−F) on the 2D diamond surface significantly influence the sp2/sp3 ratio of the carbon atoms in the layer. As the coverage is reduced, both the band gap and magnetic moment decrease. When the 2D diamond is placed between gold contacts and functionalized with (−OH), it results in a device with lower resistance compared to the (−F) functionalization. We predict that the maximum current achieved in the device increases with decreasing (−OH) surface coverage, while the opposite behavior occurs for (−F). Additionally, the surface coverage alone can alter the direction of current rectification in (−F) functionalized 2D diamonds. Similar phenomenologies are obtained for H- and OH-functionalized BN bilayers For all studied systems, a single spin component contributes to the total current for certain values of applied bias, indicating a spin filter behavior. We acknowledgd support from the Brazilian agencies CNPq, CAPES, and FAPEMIG.

Keywords: 2D materials, 2D diamond, boron nitride, electronic properties, transport properties.

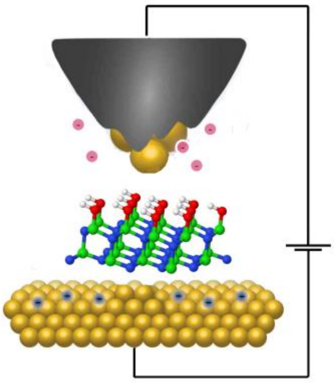

Figure 1: Schematic view of an OH-functionalized BN bilayer (in an sp3-binding phase) placed between two metallic contacts.

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1D Nanomaterials – Detailed Nanoscopic Investigations

R. Arenal[1,2,3,*]
[1] Instituto de Nanociencia y Materiales de Aragon (INMA), CSIC-U. Zaragoza, 50009 Zaragoza – Spain
[2] Fundacion ARAID, 50018 Zaragoza – Spain
[3] Laboratorio Microscopias Avanzadas, U. Zaragoza, 50018 Zaragoza – Spain

Abstract:
Transmission electron microscopy (TEM) offers a formidable capability for examining materials' structure, chemistry, and certain properties at a local scale, often down to the atomic level [1-7].

In this contribution, I will present a selection of studies conducted on different 1D nanomaterials via advanced TEM and spectroscopic measurements. I will focus on the study of misfit layered compound nanotubes (NTs) [2-4,…] as well as on functionalized carbon NTs [5,6….]. These studies demonstrate the wealth of information attainable through such experiments and underscore their relevance in studying nanomaterials. These findings enhance our understanding of these intricate nanomaterials, which is essential for investigating their physical and chemical characteristics and unlocking their potential for future applications.

Keywords: 1D nanomaterials, nanotubes, nanowires, TEM studies, electron spectroscopy investigations.

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Biopolymeric Nanofibers Functionalized with Quiral Cyclodipeptides for Energy Harvesting

D. Santos [1,2,*], R. Baptista [1], E. de Matos Gomes [1], B. Almeida [1]
[1] Centre of Physics of Minho and Porto Universities (CF-UM-UP), Laboratory for materials and Emergent Technologies (LAPMET), University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal
[2] Nanostructured Materials Group, International Iberian Nanotechnology Laboratory, Av. Mestre José Veiga s/n, 4715-330 Braga, Portugal
*id11280@alunos.uminho.pt

Abstract:
Biological building blocks, particularly dipeptides, have the ability to self-assemble into well-organized structures with functional properties, making them valuable in both biology and nanotechnology. Designed dipeptide building blocks self-assemble into diverse nanostructures enhancing their properties and versatility. These nanostructured dipeptide assemblies, with quantum confinement, hold promise in materials science as eco-friendly optoelectronic materials for energy harvesting, thanks to their biocompatibility, ease of fabrication, and functionalization.

Cyclic dipeptides, specifically aromatic cyclodipeptides with tryptophan, are versatile nanomaterials with remarkable properties. They self-assemble into various supramolecular structures like nanospheres, nanotubes, and nanowires, exhibiting quantum confinement and photoluminescence. Chiral cyclodipeptides can even demonstrate piezoelectric and pyroelectric properties, offering potential applications in nano energy sources. These dipeptides, known for their high thermal stability and mechanical strength, are incorporated into biopolymer matrices through electrospinning to create nanofiber systems.

As such, here we report the fabrication of hybrid systems based on chiral cyclo-dipeptide L-Tryptophan-L-Tryptophan and cyclo-L-Tryptophan-L-Tyrosine incorporated into biopolymer electrospun fibers [1,2]. The micro/nanofibers contain self-assembled nanostructures embedded into the polymer matrix, are wide-band gap semiconductors with 4.0 eV bandgap energy, and display blue photoluminescence as well as relevant piezoelectric and pyroelectric properties. A piezoelectric nanogenerator was proposed, tested and shown to be capable of producing 0.18 μWcm^{-2} of power density and have a piezoelectric coefficient of 57 pCN^{-1} for Cyclo (L-Trp-L-Trp)@PLLA. Therefore, the fabricated hybrid mats are promising systems for future thermal sensing and energy harvesting applications [1].

Keywords: nanofibers, cyclodipeptides, electrospinning, energy harvesting, piezoelectricity, pyroelectrocity, tensile strength.

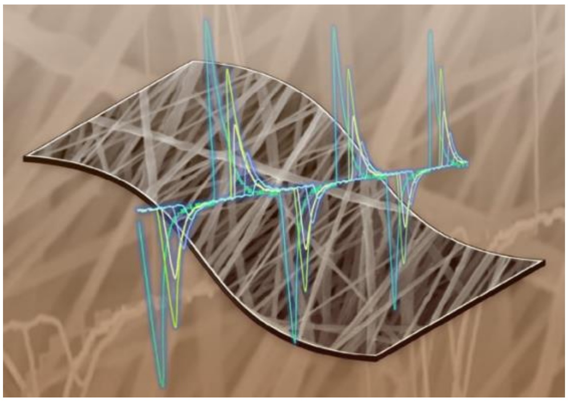

Figure 1: Figure illustrating nano-scale dipeptide self-assembled structures. Aromatic cyclodipeptides, especially those with tryptophan, display strong piezoelectric properties, showing great promise for nanoenergy harvesting.

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Enhanced performance of Li-ion battery electrodes protected by atomic layer deposited oxide films.

K. Frohlich [1,2,*], P. Sahoo[1], A. Güneren [1,3], B. Hudec[2]
[1] Centre for Advanced Materials Application, Slovak Academy of Sciences, Bratislava, Slovakia
[2] Institute of Electrical Engineering, Slovak Academy of Sciences, Bratislava, Slovakia
[3] Institute of Inorganic Chemistry, Slovak Academy of Sciences, 845 36 Bratislava, Slovakia

Abstract:

Li-ion batteries will dominate the market in the next period for high-energy demanding applications such as electric vehicles and plug-in hybrid electric vehicles. Despite their wide adoption, Li-ion batteries face challenges that result in degradation of electrochemical performance due to uncontrolled growth the solid electrolyte interphase layer at the electrodes. Atomic layer deposition (ALD) has emerged as a powerful technique, capable to protect the electrodes and eliminate their degradation.[1–3] ALD layer can be conformally grown on the entire surface of the porous electrode, including the open pores and thereby effectively protect the electrodes. Graphite and composite silicon/graphite anodes were used in this study. Silicon and graphite were prepared by ball milling, carbon black and sulfonated alginate were added as conductive agent and binder, resp. Slurry was casted on a copper foil and dried 24 hours at 100 °C. Typical thickness of the anode was 20 µm. Commercial cathode $LiFePO_4$ (NEI Corp.) was used as a cathode. The anodes and cathodes were coated using ALD by ZnO and Al_2O_3 thin films, resp. The deposition was performed at 100 °C. Parameters of the ALD deposition were modified to achieve conformal coating of the porous electrodes. The ALD coated anodes were tested in a coin cell geometry in the half cell configuration using Li counter electrode. Effect of ALD coating layers on the performance of the silicon/graphite anode is demonstrated in the Figure 1, where a discharge specific capacity is plotted against number of cycles at different charging/discharging rates (C-rates). Discharge capacity of the silicon/graphite anode coated with 20 cycles of ZnO is about 5 times higher than the unprotected pristine silicon graphite anode. Very similar results were achieved for the graphite anode coated also by ZnO ALD films. Alternatively, the electrochemical measurements were carried out in a full cell configuration using graphite anode and $LiFePO_4$ cathode. In this case $LiFePO_4$ cathode was coated by 2, 5, 10 and 20 cycles of Al_2O_3. The full cell battery exhibited improved rate capability for the c-rates 1 and 2 and enhanced cycling stability. In conclusion, ALD protected Li-ion battery electrodes exhibit enhanced performance in terms of rate capability and cycling stability.

Keywords: Li-ion battery, silicon/graphite anode, $LiFePO_4$ cathode, atomic layer deposition, ZnO and Al_2O_3 thin films.

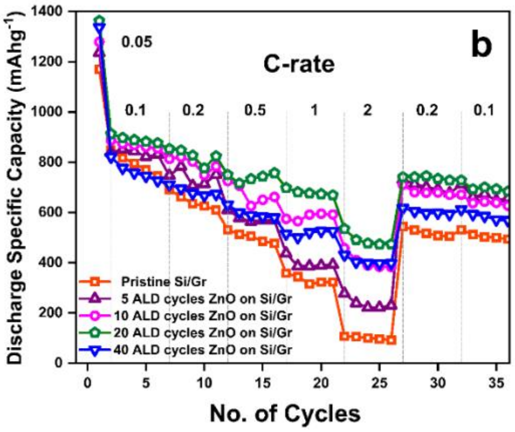

Figure 1: Discharge specific capacity of the Li-ion silicon/graphite anode coated by 5, 10, 20 and 40 ALD cycles of ZnO as a function of cycles at different charging/discharging rates (C-rates). ALD coated anodes exhibit enhanced capacity compared to the unprotected pristine anode especially at C-rates 1 and 2.

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Unveiling the Potential of Textile Beeswax Triboelectric Nanogenerators for Sustainable Energy Processing

E. Kovalska [1*], H. T. Lam, [2] Z. Saadi, [1] R. Mastria, [2,3] A.I.S. Neves, [1] S. Russo, [2] M.F. Craciun [1]
[1] Department of Engineering, Faculty of Environment, Science and Economy, University of Exeter, EX4 4QF, Exeter, United Kingdom
[2] Department of Physics and Astronomy, Faculty of Environment, Science and Economy, University of Exeter, EX4 4QL, Exeter, United Kingdom
[3] Institute of Nanotechnology, CNR NANOTEC, c/o Campus Ecotekne, via Monteroni, I-73100, Lecce, Italy

Abstract:

Groundbreaking progress in various fields, encompassing healthcare, environmental sciences, space exploration, communication, and defence heavily rely on the integration of cutting-edge self-powered sensing technologies within textiles. A pivotal breakthrough in this field involves the emergence of sustainable self-powered sensors specifically triboelectric nanogenerators (TENG). The fundamental principle of TENG involves leveraging the triboelectric effect, which relies on the interaction between materials with different electronegativity and electrostatic induction. TENG devices can effectively harness untapped energy resources, for example, they can convert acoustic energy into electricity. TENG-based sound detectors are emerging as a practical alternative to battery-powered devices, given their self-powered and environmentally friendly characteristics. Ideally, these energy harvesters should be widely accessible at low cost and have a low carbon footprint in their production, achieved, for instance, by utilising natural raw materials that require minimal post-processing. To pave the way for these transformative advancements, it is crucial to develop flexible, mechanically robust, lightweight, and resilient TENG-driven acoustic sensors.

In my talk, I will present our recent work on a pioneering approach to address the current energy challenge by demonstrating the development of beeswax-based TENG. This environmentally friendly and yet unexplored solution to the design and fabrication of seamless nanogenerators on textiles is shown to produce viable electric output upon solicitation from any form of mechanical energy including ambient acoustic noise, vibrations, human voice, touch, and rubbing to list a few. While beeswax has gained limited attention in the electronics industry, primarily in applications such as printed circuit boards and soldering flux additives for improved adhesion, its untapped potential as an active electronic material remains unexplored. This study uncovers, for the first time, the remarkable electronic properties of beeswax, highlighting its significant role in electronic devices, particularly in the realm of energy harvesting and sensing textiles. I will discuss how the unique combination of electrical, morphological, and mechano-elastic properties positions beeswax as an exceptionally attractive candidate for advancing energy harvesting and sensing textile technologies.

The thermal-induced self-healing and self-cleaning features of beeswax facilitate the efficient harvesting of acoustic pollution, low-frequency ground-borne vibrations, and conversational sounds. This capability remains effective even in challenging conditions, including high humidity and mechanical bending. Additionally, investigations reveal that the textile-beeswax TENG not only serves as a sound detector but also functions as a self-powered microphone. It produces distinctive electrical signals in response to human voices, demonstrating increased sensitivity to male voices and emotional speech. This discovery opens up intriguing possibilities for innovative applications in voice recognition and emotion detection systems. Moreover, the results underscore the potential of the textile-beeswax TENG as an acoustic hybrid energy harvester, capable of converting both acoustic pollution and mechanical vibrations, such as those from working engines, into practical electrical energy.

Keywords: beeswax, energy harvesting, triboelectric nanogenerators, textile power sources, self-powered devices.

Stability of inorganic perovskites nanocrystals: what is at the end of the tunnel?

P.K. Mubiayi [1]
[1] Molecular Science Institute, African Research Universities Association- Center of Excellence in Materials for Energy and Nanotechnology, University of Witwatersrand, Johannesburg, South Africa

Abstract:
Perovskites nanocrystals possess interesting properties researchers seek to overcome current technological challenges. Perovskite properties can be improved by engineering their structure through additional cations and/or their mixture with chalcogenide compounds. One of the main properties is stability, which may be affected by environmental conditions, surface atomic structure, decomposition energy, etc. Improving the performance of existing or new devices is the main aim set by scientists when studying nanoparticles. Inorganic perovskite nanocrystals were prepared via classical colloidal method and microwave assisted method. Various parameters of synthesis including the time, temperature, precursor concentration, coordinating solvent and capping agent were investigated. Their properties were studied and optimized for effective application in photovoltaic devices. Photocatalytic performance was evaluated from perovskite and their composites. Furthermore, several types of solar cell devices as well as perovskite cells were prepared from thin film of synthesized nanocrystals and the evidence of photovoltaic activity was shown. The performance of fabricated devices was influenced by the structure of deposited thin films, especially the absorbing layer made of synthesized nanocrystals.

Keywords: perovskites, preparation, stability, green energy.

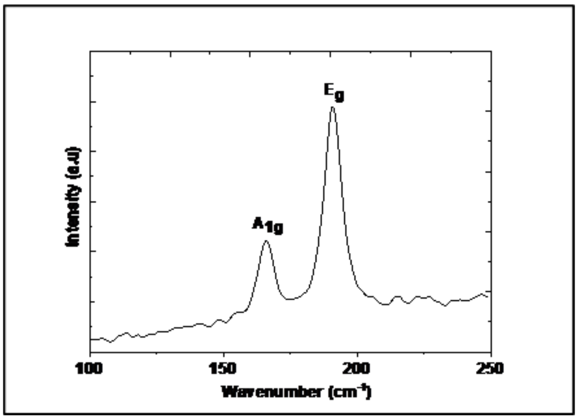

Figure 1: Raman spectrum of inorganic cesium-based perovskites NCs with optimized stability.

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Toward Flexible Piezoelectric III-Nitride Nanowire-based Nanogenerators

N. Buatip[1,*], P. John[2], T. Auzelle[2], F. Donatini[1], S. Le Denmat[1], B. Fernandez[1], M. Saluan[1], and R. Songmuang[1]
[1] Université Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France
[2] Paul-Drude-Institut für Festköperelektronik, Hausvogteiplatz 5-7, 10117 Berlin, Germany

Abstract:

Nanogenerators (NGs), utilizing wurtzite piezoelectric nanowires (i.e., ZnO and III-Nitride), have emerged as a compelling innovation with significant potential in self-powered sensors and nanoscale power systems[1]. Notably, AlN nanowires exhibit a high piezoelectric coefficient alongside a large bandgap of 6.2 eV, effectively minimizing piezo-charge screening generally observed in ZnO. The intrinsic characteristics of AlN, synergized with the inherent mechanical flexibility of nanowires, should enhance the performance of nanogenerators. However, AlN nanowire-based NGs have not been widely explored.

In this context, we initially present the direct piezo-response of AlN nanowire-based NGs on TiN/Al_2O_3, as depicted in Figures 1(a)-(b). The purpose is to assess their Figure of Merit (FoM), specifically the piezoelectric voltage constant (g), and the product $g{\cdot}d$, where d represents the piezoelectric charge constant[2]. The extracted g constant implies that the nanowires exhibit superior mechanical sensing capabilities in comparison to single crystal GaN and quartz bulk substrates. Simultaneously, the product $g{\cdot}d$ suggests that the nanowires possess a comparable ability for energy generation.

Beyond performance considerations, the flexibility of entire devices is increasingly in demand for conformal device integration on various surfaces. In this regard, we have developed a protocol to peel-off high-density nanowires from the host rigid substrates (Figure 1(c)) and transfer them onto the flexible ones e.g. polymer or paper. The process involves wet chemical etching and nanowire encapsulation using polydimethylsiloxane (PDMS). We show that the silanization of the nanowire surface prior to the PDMS encapsulation significantly improves the yield of transfer process on a large scale. This improvement is attributed to the enhanced bonding between the PDMS and the nanowire surface. To assess the functionalities of the flexible NGs, electrical contacts are processed on the nanowire-PDMS composites to connect them to the external circuit. Our studies should offer useful technological processes and measurement protocols, applicable not only to nanowire-based NGs but also other nanostructured piezoelectric harvesters.

Keywords: piezoelectric composites, III-Nitride nanowires, flexible nanogenerators.

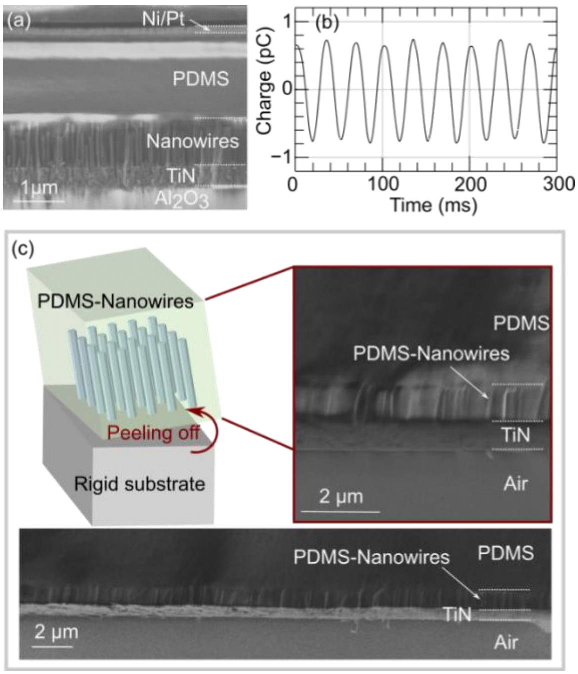

Figure 1: (a) Scanning electron microscopy (SEM) image of AlN nanowire-based NGs. (b) The piezo-charge response signal of this device during a sinusoidal force excitation of 30 Hz with a force amplitude of 440 mN. (c) Schematic of the peeling-off process of the PDMS-nanowire composite layer and the corresponding SEM image of the suspending composite layer.

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Are fractals useful for supercapacitor applications? – A case of Fe_2O_3 negative electrodes

Rishabh Jaiswal [1], Garima Chaturvedi [1], Vikas Sharma [1], S. A. Ilangovan [2], S. Sujatha [2], K.S. Ajeesh [2],Sankara Sarma V. Tatiparti [1,*]
[1] Department of Energy Science and Engineering, Indian Institute of Technology Bombay, Mumbai, India
[2] Advanced Power Systems, VSSC, Thiruvananthapuram, India

Abstract:

Materials for supercapacitor applications need high specific surface area to encourage surface charge storage. Hence, several types of morphologies e.g. nanoflowers, nanorods, nonofibres etc. have been engineered for these applications by various research groups. Most of these materials show excellent charge storage performance.

Recently, a different class of morphologies viz. ‘Fractals’ – spatially self-repeating structures – have been explored for supercapacitors. Hota et al. reported that fractals of RuO_2 exhibit the highest areal capacitance of ~11 mF cm^{-2} at 0.1 mA cm^{-2}. We recently demonstrated that fractal-like structures of Fe_2O_3 show a remarkable performance of ~2700 F g^{-1} at 1 A g^{-1}. Inevitably, fractals always have the surface area effects coupled with them. Hence, a morphology with large fractal dimension can possess high specific surface area.

Consequently, some questions are: (i) Are fractals indeed useful for supercapacitor applications? (ii) Can fractality be exploited? (iii) How to decouple surface area effects from fractality? (iv) What are the exclusive effects of the fractal on charge storage mechanism?

These questions are addressed here by studying Fe_2O_3 – a constituent of the commonly available iron oxide – as a negative electrode material. Fe_2O_3 was hydrothermally synthesized in Fern, Flake and Microsphere morphologies with similar specific surface areas. This was purposefully done to keep the surface area effects the same across these morphologies. The negative electrodes are fabricated by supporting them on nickel foam (NF). The fractal dimensions of these morphologies were estimated geometrically and from electrochemical impedance spectroscopy (FD_{EIS}). The estimated FD_{EIS} for Ferns, Flakes and Microspheres are ~2.50, ~2.36 and ~2.19, respectively. The Fern@NF electrode exhibits the highest specific capacitance (C_{sp}) of ~2708 at 1 A g^{-1}, respectively with a ~94% capacitance retention after 2000 charge/discharge cycles. Interestingly, the non-Faradaic capacitive surface charge storage from cyclic voltammetry increases with FD_{EIS} from Microspheres to Ferns. Often, this surface charge storage contribution is modelled using constant phase element (Z_{CPE}) in equivalent electrical circuit. Our study shows that Z_{CPE} scales inversely with FD_{EIS}. Thus Ferns, with the highest FD_{EIS} exhibit the lowest Z_{CPE}, leading to the highest C_{sp} (Figure 1).

Hence, fractal-like structures are useful for supercapacitor applications by promoting capacitive surface charge storage through low Z_{CPE}. Fractality of the morphology can be exploited in supercapacitor applications as it is a natural feature in some morphologies of materials which grow freely in nature – e.g. Iron oxide.

Keywords: fractal, iron oxide, supercapacitor, impedance, charge storage, capacitance.

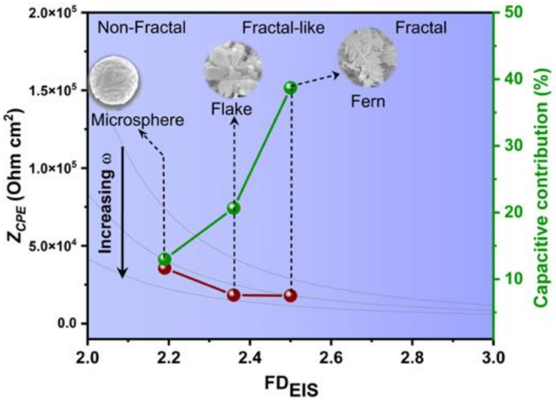

Figure 1: Lower Z_{CPE} leads to higher capacitive contribution in morphologies with larger fractal dimension (FD_{EIS}).

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Nanotech France / GAMS / Biotech France 2024 Joint Session II.C: Nano for life science and Medicine

Plasmonics Nanosensors and Nanoprobes: A New Generation of Nanoplatforms for Diagnostics and Treatment of Cancer

Tuan Vo-Dinh
Fitzpatrick Institute for Photonics, Departments of Biomedical Engineering and Chemistry, Duke University, Durham, North Carolina, USA

Abstract

This lecture will delve into the developments within our laboratory on advanced nanoparticle-based technology for medicine. Our focus revolves around the interaction of laser radiation with metallic nanoparticles, aimed at early cancer diagnostics and treatment. This process, known as 'plasmonic enhancement,' results in the generation of the surface-enhanced Raman scattering (SERS) effect, amplifying the Raman signal of molecules on these nanoparticles by over a millionfold. At the core of our nanosensing platforms are gold nanostars (GNS) with multiple sharp branches, exhibiting ultrabright SERS signals for diagnostics. We have pioneered several biosensing technologies, such as the 'Inverse Molecular Sentinel' and 'Nanorattle' probes. These nanoplasmonic biosensors provide a versatile and powerful diagnostics technology for a class of important molecular biomarkers including DNA, microRNAs, and mRNAs linked to various diseases such as cancers (e.g., breast, gastrointestinal, and head and neck cancer) and infectious diseases. The capability to simultaneously detect genomic target biomarkers stands out as a pivotal factor in the early diagnosis of diseases, even before physiological symptoms manifest. In particular, the development of practical and highly sensitive detection techniques endowed with extensive multiplexing capabilities holds the promise of advancing precision medicine and enhancing the accuracy of disease diagnosis.

Beyond detection, there is an urgent clinical demand for novel strategies in the effective treatment of cancer, particularly in unresectable metastatic tumors. Leveraging the plasmonics-active GNS nanotechnology, we have developed SYnergistic iMmuno PHOtothermal NanotherapY (SYMPHONY), a therapeutic approach that integrates nanotechnology, biophotonics, and immunotherapy. Our research outcomes have revealed that combining nanoparticle photothermal therapy with PD-1/PD-L1 immune checkpoint blockade results in a synergistic effect, surpassing the efficacy of either therapy alone. SYMPHONY has produced an immensely potent systemic response in curing both primary and distant lesions in a murine model and creating a long-term immune response like an ‘anti-cancer vaccine' effect to prevent future cancer recurrences.

Nanovesicles as Tools to Protect the Skin against Environmental Stressors

E. Esposito[1*], M. Sguizzato[1], F. Ferrara[1], A. Bondi[1], W. Pula[1], M. Benedusi[2], L. Calderan[3], M.G. Ortore[4], M. Malatesta[3], G. Valacchi[3,5]
[1]Dept. Chemical, Pharmaceutical and Agricultural Sciences, University of Ferrara, Italy
[2]Dept. Environmental Sciences and Prevention, University of Ferrara, Italy
[3]Dept. Neurosciences, Biomedicine and Movement Sciences, University of Verona, Italy
[4]Dept. Life and Environmental Sciences, Polytechnique University of Marche, Ancona, Italy
[5]Animal Science Dept., Plants for Human Health Institute, NC Research Campus, NC State University, Kannapolis, USA

Abstract:

Environmental pollution is one of the main concern affecting the human health. Particularly, chemical and physical pollutants, such as particulate matter or UV light, can be responsible of cutaneous deleterious effect, leading to disorders such as erythema, edema, hyperplasia, aging, contact dermatitis, atopic dermatitis, psoriasis, and melanoma. Nature represents an inestimable source of phytocompounds suitable to treat many pathologies and disorders. Recently, the strategy of phytocompound nanoencapsulation demonstrated to maintain their stability, prolonging their action. Indeed natural bioactive compounds derived from edible plants can prevent or counteract serious diseases. For instance, curcumin, mangiferin, quercetin and kaempferol are potent antioxidants, representing potential skin cancer chemo-preventive agents, due to their anti-inflammatory and immunomodulatory activity. Despite the pharmacological potential of these phytocompounds, low solubility and stability drawbacks hamper their pharmaceutical use, requiring specialized delivery systems based on nanoplatforms. Particularly, ethosomes and transethosomes are biocompatible nanovesicular systems based on phosphatidylcholine, ethanol and water, suitable for transdermal delivery, providing a low toxicity profile. We demonstrated the capability of ethosomes and transethosomes to entrap phytocompounds protecting them from degradation. The nanoencapsulation of phytocompounds enabled to improve their stability and to prolong their action, promoting their transdermal delivery. The antioxidant and anti-inflammatory effect of ethosomes and transethosomes loaded with phytocompounds was demonstrated on human keratinocytes exposed to cigarette smoke, as an oxidative and inflammatory challenger, and on 3D human skin models exposed to ozone, suggesting the possibility to protect cells from pollutant damage, in order to prevent and treat skin conditions associated to ox-inflammatory mechanisms. Remarkably, a recent cryogenic transmission electron microscopy study conducted on human skin explants revealed that the vesicles are able to penetrate the epidermal barrier, crossing the stratum corneum through the intercellular space, and entering the corneocytes, confirming their suitability as transdermal delivery systems, confirming the possibility to treat inflammatory disorders affecting the skin, mainly induced by oxidative stressors.

Keywords: skin, ethosome, antioxidants, phytocompound, environmental stressors.

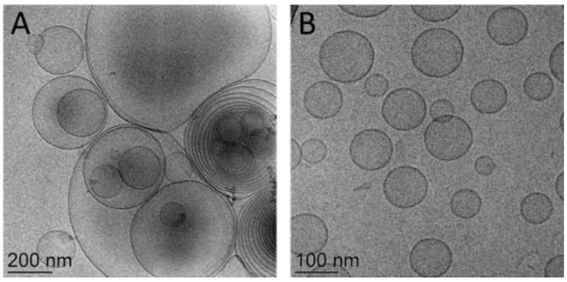

Figure 1: Cryogenic transmission electron microscopy, employed to study the vesicle morphology, revealed a multilamellar (A) or unilamellar (B) supramolecular structure, in the case of ethosomes and transethosomes respectively.

References:

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Acknoledhment

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Nanoencapsulation: From 1D van der Waals Heterostructures to Cancer Therapy

Gerard Tobías-Rossell
Institut de Ciència de Materials de Barcelona (ICMAB-CSIC), Bellaterra, Spain

Abstract:

In this talk we will review some recent progress on the design and nanoengineering of carbon and inorganic nanomaterials for tailored applications. Special emphasis is paid in the group to exploit the synergies of both types of materials by the preparation of nanohybrids with novel or enhanced properties. A large deal of attention is being devoted towards the isolation and growth of single layers of a wide variety of inorganic materials which is of interest for both fundamental research and advanced applications. When an individual layer is seamlessly wrapped into a cylinder, the resulting single-layered nanotube combines the characteristics of both two-dimensional (2D) and one-dimensional (1D) materials. Yet, despite their interest, reports on single-walled inorganic nanotubes are scarce because their multiwalled counterparts are in general favoured during growth. We have reported on a versatile approach that allows the formation of high quality, single-crystalline single-layered inorganic nanotubes (Figure 1).[1] Among the different types of carbon nanomaterials, one advantage of using carbon nanotubes and carbon nanohorns is that their inner cavity can be filled with a chosen payload whilst the outer surface can be modified with biomolecules to improve their dispersibility, biocompatibility and even for targeting purposes. For instance, following this approach we have shown that by filling radioactive isotopes it is possible to achieve ultra-sensitive imaging and the delivery of an unprecedented amount of radiodose density thus allowin their use for cancer therapy.[2-4] Furthermore, we have recently expanded this approach to the encapsulation of ^{6}Li for their use as neutron capture therapy agents, for LiNCT (Fig. 2).[5,6]

Keywords: carbon nanotubes, 2D materials, van der Waals heterostructures, cancer, BNCT, neutron capture therapy.

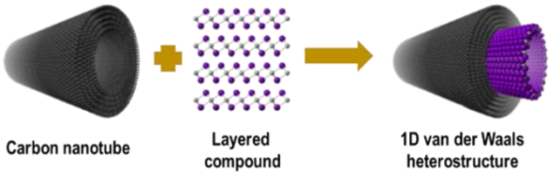

Figure 1: Schematic representation of synthesis of 1D tubular van der Waals heterostructures.

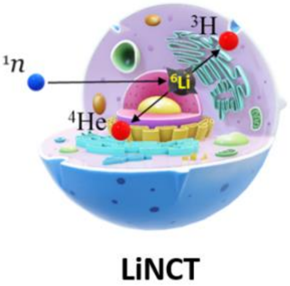

Figure 2: Schematic representation of lithium neutron capture therapy (LiNCT) to kill cells.

References:

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6. Tobias et al., Lithim filled nanocapsules and use thereof. Patent WO2023180615

Graphene functionalization towards biodegradability

S. Rahimi [1,*], M. Bahmani [1], I. Mijakovic [1,2,*]
[1] Department of LIFE sciences, Chalmers University of Technology, Gothenburg, Sweden
[2] The Novo Nordisk Foundation Center for Biosustainability, Technical University of Denmark, Lyngby, Denmark

Abstract:

There is a great potential for graphene oxide (GO) nanosheets as the promising materials for drug delivery. The toxicity of these materials and their biodegradation are the issues that need to be addressed before their clinical applications. To reduce the toxicity of GO itself as the drug carrier, we previously conjugated GO with with antioxidant ginsenoside Rg3, a tetracyclic triterpenoid saponin naturally present in ginseng plant. It significantly reduces the toxicity of the GO carrier by abolishing ROS production and not inducing IL17-directed JAK-STAT signaling and VEGF gene expression—nor cell proliferation as the unwanted side effects. Based on that, we proposed GO–Rg3 as an effective, biocompatible, and pH responsive DOX carrier with potential to improve chemotherapy—at least against liver and breast cancers.

Towards the biodegradation of GO, we for the first time investigate the biodegradation of GO functionalized materials with polyethylene glycol (PEG) and polyethyleneimine (PEI) and compare it with GO itself. To aim this, we firstly produced GO conjugates with PEG and PEI. Then, we examined the biocompatibility of differentiated granulocyte-like cells once they were treated with GO, GO-PEG, and GO-PEI. The biodegradation of these materials by the granulocyte-like cells, Neutrophil Extracellular Traps (NETs) collected from the differentiated granulocyte-like cells, and MPO the key enzyme in NETs were assessed using Raman spectroscopy and TEM. The results showed that the cells were also able to biodegrade GO-PEI verified by higher D/G ratio. Biodegradation of GO-PEI were also shown by NETs and MPO. Transmission electron microscopy (TEM) imaging also showed porous structure of GO-PEI samples once they were treated to the differentiated granulocyte-like cells.

Keywords: graphene oxide, neutrophils, Neutrophil Extracellular Traps, biodegradation

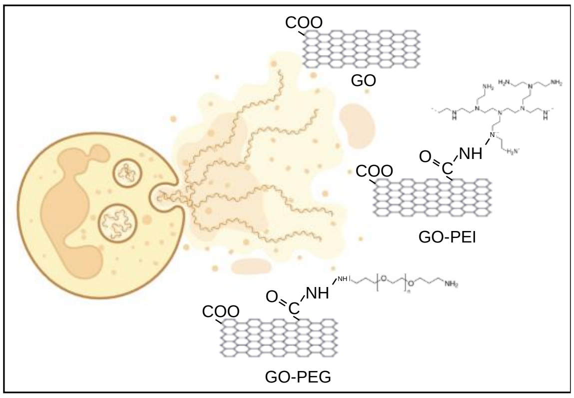

Figure 1: Figure illustrating the fundamental question that we are tempting to solve experimentally: graphene functionalization would affect the biodegration of GO using neutrophils.

References:

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Quantification and characterization of manufactured nanomaterials shed from non-medical face masks

R. Mehri[1], Z. Gajdosechova[2], T.A. Sipkens[1], J.C. Corbin[1], A. Belknap[3*], D. Vladisavljevic[3], G.J. Smallwood[1]
[1] Aerosol and Gas Metrology, National Research Council Canada, Ottawa, Canada
[2] Inorganic Chemical Metrology, National Research Council Canada, Ottawa, Canada
[3] New Substances Assessment and Control Bureau, Health Canada, Ottawa, Canada

Abstract:
The Government of Canada conducts risk assessments of substances under the Canadian Environmental Protection Act (CEPA) to determine whether they present or may present a risk to human health or to the environment and has committed to addressing nanoscale forms of substances on the Domestic Substances List (DSL). Face masks, including non-medical, textile masks available to consumers, are an important public health measure whose use became widespread during the COVID-19 pandemic. Manufactured nanomaterials (MNMs) have been used in non-medical face masks to enhance their anti-microbial, anti-bacterial and self-cleaning properties. There is currently a data gap in the published literature on the shedding potential of component MNMs as it relates to inhalation uptake.

For this purpose, three different commercially available face masks, claiming to contain TiO_2, were analyzed with regard to: 1) their composition (including elemental mass fraction) and 2) particle shedding. Masks were digested and analyzed with Inductively Coupled Plasma Mass Spectrometry (ICP-MS) to determine the mass fraction for target elements (Ti, Ag). Water extracts of the masks were analyzed in single particle (spICP-MS) mode for the same target elements to quantify the size distribution of particles removed from the mask by continuous agitation in water. Scanning electron microscopy-energy dispersive X-ray (SEM-EDX) analysis was used to determine the morphology, location and elemental composition of the particles in the masks.

Masks were then tested in a custom-built Particle Filtration Efficiency Measurement System (PFEMS) under continous air flow (Corbin et al. 2021) with and without concurrent mask agitation. Particles exiting the test chamber were measured by a scanning mobility particle sizer (SMPS), an optical particle sizer (OPS), and a condensation particle counter (CPC) to determine particle concentrations and size distributions. Particles were also captured on polyvinyl chloride (PVC) and water soluble gelatin filters for additional ICP-MS and SEM-EDX analysis.

All masks tested were found to contain different levels of Ti. Total Ti in the highest content mask ranged from approximately 1200 to 4000 µg/g, in line with previous studies (Verleysen et al. 2022). SEM-EDX shows that TiO_2 particles are clearly visible on the surface of mask fibers (Figure 1). The results also demonstrate the presence of Ti nanoparticles within the water extracts. Particle shedding was not observed for masks exposed to continuous airflow alone. However, shedding under airflow was detected with concurrent intensive agitation (vibration) of the mask.

This data will add to the body of evidence relating to inhalation uptake from shedding of nanomaterials and may inform future risk assessments.

Keywords: particle shedding, face mask, manufactured nanomaterial, titanium dioxide, risk assessment, inhalation

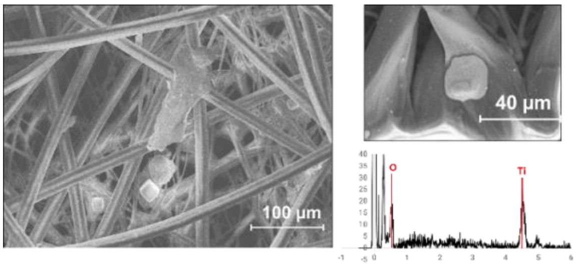

Figure 1: Left: Representative SEM image of the outer layer of mask showing irregularly shaped particles attached to the surface of the fibers; Right: Representative particle and EDX spectrum of the same particle confirming the presence of titanium dioxide (TiO_2).

References:

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Is the future of antioxidants mineral? Nanozymes and other nanotechnology solutions

Victor Puntes[1,2,3]
[1] Vall d'Hebron Research Instiute (VHIR), 08035 Barcelona, Spain
[2] Instiut Català de Nanociència I Nanotecnologia (ICN2), CSIC, The Barcelona Institute of Science and Technology (BIST), Campus UAB, Bellaterra, 08193 Barcelona, Spain
[3] Institució Catalana de Recerca I Estudis Avançats (ICREA), 08010 Barcelona, Spain

Abstract:

The role of antioxidants in biology became popular in the second half of the 20th century at times when Linus Pauling (1954 and 1962 Nobel laureate) worked on the so called orthomolecular medicine, based on nutritional supplementation and high doses of ascorbic acid. It bumped again in the 90s, as consequence of a large human study suggesting that vitamin E supplements could be associated with a reduced risk of heart diseases. During these years, other works, basically pre-clinical and epidemiological, also reported beneficial effects of antioxidant substances in chronic inflammation, neurodegeneration, and cancer. As a consequence of that, antioxidant therapies were evaluated in placebo-controlled trials involving tens of thousands of patients and, despite pathophysiologic, epidemiologic, and mechanistic compelling evidence, these clinical trials have been, to date, mostly negative. This has given rise to a pessimistic view on antioxidant therapies. This has been attributed to the non-drug-likeness of available antioxidant compounds. These compounds have high unspecific uncontrolled reactivity, poor solubility, and hence limited absorption profiles, low bioavailability and low concentrations at the target site. During this time, nanomaterials has been proposed for use in treating human diseases, primarily as drug delivery agents, showing potential benefits in terms of pharmaceutical flexibility, selectivity, dose reduction, and minimization of adverse effects. Thus, efforts have been made towards loading antioxidant molecules such us coenzyme Q10, vitamin E and vitamin A, resveratrol and polyphenols, curcumin, lycopene, silymarin, and superoxide dismutase in nanocarriers such as liposomes, polymeric NPs, lipid NPs, and self-emulsifying systems. More recently, nanotechnology has shown us how rare earth mineral antioxidant NPs, especially cerium oxide NPs, nanoceria[1], are powerful antioxidant and consequent anti-inflammatory agents that can treat many inflammation-related diseases. This is a new paradigm, where the nanoparticle itself, thanks to its nanometric form and high concentration of oxygen vacancies at its surface, is the active principle, not a vehicle. Interestingly, nanoceria is safe, xenobiotic, and highly traceable material.

Keywords: cerium oxide nanoparticles, reactive oxygen species, antioxidant substances, inflammation and metabolism.

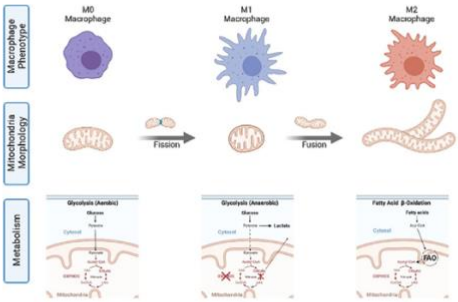

Figure 1. Macrophage phenotypes, mitochondria morphology and corresponding catabolic pathways.

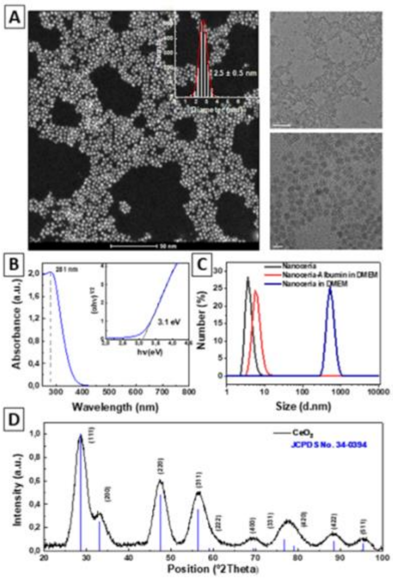

Figure 2. Electron microscopy (HAADF and (HRTEM), UV.vis spectra, DLS distribution and XR diffraction of nanoceria.

References:

1. Lena Montana-Ernst and Victor Putes Frontiers in immunology, 2022 (13), 750175

Investigating hybrid lipid-PLGA nanoparticles loaded with an endogenous endocannabinoid-like molecule for targeting inflamed muscle

E. Leo[1], S. Molinari[1], E. Maretti[1] C. Rustichelli[1]
[1] Department of Life Sciences (DSV), University of Modena and Reggio Emilia, Modena, Italy

Abstract:

Palmitoylethanolamide (PEA) is an endogenous lipid molecule with an endocannabinoid-like structure involved in regulating various processes, including pain perception and modulation of inflammatory states. Today, it is utilized in nutritional supplements, cosmetics, and medical devices. However, owing to its potent analgesic, neuroprotective, and anti-inflammatory effects, it holds promise for treating various pathologies, including muscle inflammatory diseases like sarcopenia (1, 2). Nevertheless, medical employment of PEA is hampered by its low solubility and consequent difficulty in crossing biological barriers. To address this issue, poly-lactic-co-glycolic acid nanoparticles (npPLGA) can be proposed. However, the encapsulation of such a small lipid molecule into PLGA nanoparticles poses a challenge. We report here the development and the characterization of a new hybrid lipid-PLGA nanoparticles designed for PEA delivering. The new hybrid nanoparticles were developed starting from conventional PLGA nanoparticles which were unable to encapsulate PEA. After several attempts, a lipid-PLGA formulation reaching 80% of PEA encapsulation efficiency (EE) was standardized. PEA-hybPLGA nanoparticles were characterized dimensionally by Zetasizer PRO and morphologically through scanning and transmission electron microscopy (SEM and TEM). A size of approximately 100 nm and predominantly spherical shape (Figure 1) was observed. Coumarin 6-labeled nanoparticles were adopted in the *in vitro* study on C2C12 murine muscle cells. Cytotoxicity, evaluated using the MTT test, revealed a lower citotoxicity for PEA-hybPLGA nanoparticles compared to empty ones. Moreover, flow cytometric and confocal microscopy analysis have demonstrated an high efficiency of internalization by both proliferating and differentiated muscle cells. Further studies on cells inflamed with LPS are underway.

Keywords: sarcopenia, solid lipid nanoparticles, polymeric nanoparticles, scanning and transmission electron microscopy, C2C12 muscle cells, LPS induced inflammation.

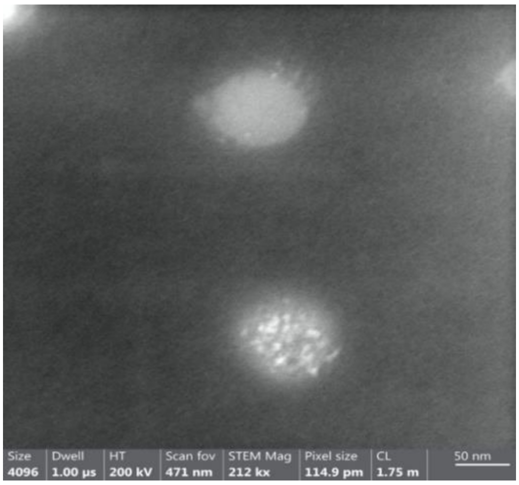

Figure 1: Figure illustrates a STEM image obtained by TEM (TEM, Talos F200S G2, Thermo Fischer Scientific) at high magnification of PEA-hybPLGA nanoparticles. It is possible to see the polymeric matrix in which small aggregates of PEA and lipid can be distinguished.

Founding: This work was funded by the “European Union–Next Generation EU” n. P2022LSW98 (PRIN-PNRR to E.G. Leo)

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Pathogen-associated molecular pattern-coated inorganic nanocarriers: a biomimetic approach for subunit vaccines

L. M. López-Marín[1,*], C. Valdemar[1], A. Cuán[2], R. Nava[2], R. Avila[1]
[1] Universidad Nacional Autónoma de México, Centre of Applied Physics and Advanced Technology, UNAM Campus Juriquilla, 76230 Querétaro, Mexico
[2] Universidad Autónoma de Querétaro, Facultad de Ingeniería, UAQ Campus Aeropuerto, 76140, Querétaro, Mexico

Abstract:

Vaccine development constitutes a key factor in public health, with opportunities against both communicable and non-communicable diseases. Upon the emergence of the COVID-19 pandemics, subunit vaccines have been strengthened as one of the best options to produce vaccines at a very large scale. Due to safety reasons, the use of non-viral vaccine vectors is being widely investigated. To date, particles of well-defined surface chemistries, sizes or targeting properties can be rationally designed through molecular engineering[1]; on another side, a set of biocompatible organic/inorganic structures are being described to encapsulate or display molecular structures. In this regard, easiness and low-cost also appear as a necessity, especially for the manufacturing of vaccines intended for low-income settings. In this work, a nanoporous silica carrier, aimed to incorporate macromolecular cargoes, was produced through simple, low-cost procedures. Then, self-assembly processes were used to coat the inorganic particles using biomimetic, pathogen-associated molecular pattern (PAMP)-containing lipid bilayers[2]. Ultrastructure, physicochemical and spectroscopy analyses were used to characterize the nanostructure. Then, cytotoxicity, cytokine production and confocal microscopy analyses were performed to assess the immunogenicity profile of the as-designed vector in THP1-derived macrophage cells. Our results showed that PAMP-decorated silica represents an immunogenic, though biocompatible, and low-cost vaccine nanocarrier. Further research is underway to explore the ability of our construct for vaccine subunit delivery.

Keywords: vaccine delivery, nanoporous silica, liposomes, supported lipid bilayers, biomimetism.

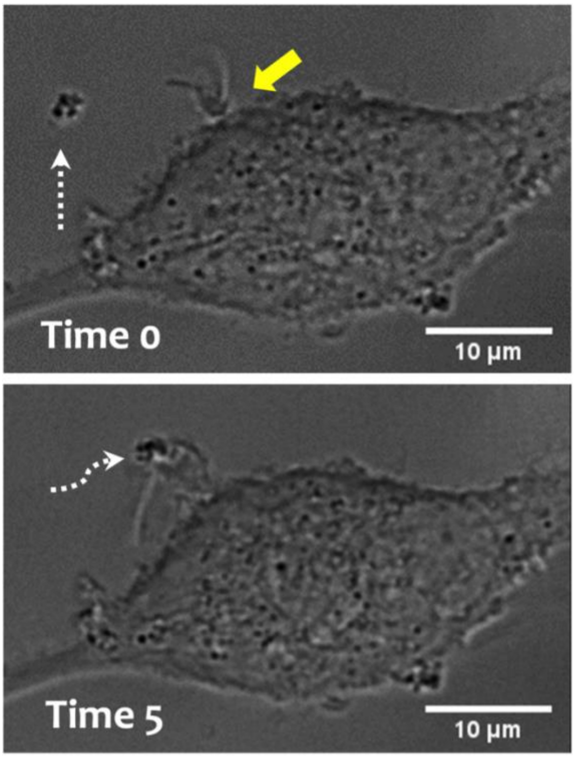

Figure 1: Exposure of macrophages to PAMP-coated nanocarriers showed a quick remodelling of the cell surface, with the formation of pseudopods surrounding the particles, leading to particle uptake in a matter of seconds. Time lapses are showed in seconds.

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Reprogramming Tumor-Associated Macrophages: Utilizing mUNO-Conjugated Gold Nanoparticles in Combination with X-ray Irradiation

Z. Kayani [1], S; Iyer [1], A-C. Heuskin [1]

[1] Laboratory of Analysis by Nuclear Reaction–NARILIS, University of Namur, Namur, Belgium

Abstract:
Tumor-associated macrophages (TAMs) play a crucial role in tumor progression, metastasis, and treatment resistance. Their plasticity along the M1-M2 polarization axis determines their functional roles, with M2-like TAMs typically promoting tumor growth and metastasis, while M1 macrophages possess antitumor properties. Redirecting TAM polarization towards an M1-like phenotype represents a promising strategy for enhancing tumor regression. In this study, we successfully reprogrammed M2 to an antitumor M1 phenotype using vectorized gold nanoparticles combined with X-ray irradiation. These gold nanoparticles were functionalized with a peptide called mUNO, which specifically interacts with the mannose receptor type 1 (MRC-1) overexpressed in M2 TAMs. By targeting M2 via nanoparticles and simultaneously irradiating them, the metabolic pathways of M2 TAMs are affected, inducing a switch to the M1 phenotype. Collectively, our findings suggest that this innovative therapeutic nanoagent, in conjunction with X-ray radiotherapy, holds promise for improving cancer treatment outcomes by reprogramming M2-like TAMs towards an antitumoral phenotype.

Keywords: Tumor-associated macrophages (TAMs), Nanoparticle, Radiotherapy (RT), Macrophage polarization, Cancer therapy

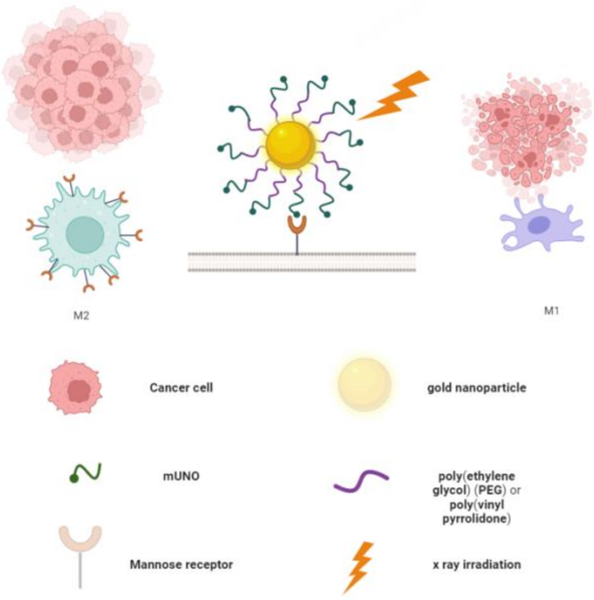

Figure 1: Illustration depicting the targeted nanoparticle therapy strategy for cancer immunoradiotherapy. Gold nanoparticles coated with polyethylene glycol (PEG) or polyvinylpyrrolidone (PVP) are functionalized with a specific peptide called mUNO, designed to bind to mannose receptor type 1 (MRC1) overexpressed on M2-like macrophages in the tumor microenvironment. Upon binding and internalization of the functionalized nanoparticles, followed by X-ray irradiation, M2-like macrophages undergo a phenotypic switch to M1-like macrophages, characterized by enhanced anti-tumor activity, leading to the killing of cancer cells.

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Development of hybrid nanomaterials based on AuNR@MOF/CCMoid to improve the detection of metal ions by fluorescence emission

C. Araneda[1,2*], N. Parra[1], P. Cabrera[2], M. J. Kogan[2], M. Soler[1]
[1]Department of Chemical Engineering, Biotechnology and Materials, University of Chile, Santiago de Chile, Chile.
[2]Department of Pharmacological and Toxicological Chemistry, University of Chile, Santiago de Chile, Chile
catherine.araneda.f@gmail.com

Abstract:

One of the factors that trigger the pathogenesis of Alzheimer's Disease is the accumulation of certain types of metal ions (1) and one of the non-invasive techniques used for their detection is by fluorescence emission in the nearIR range.

This research is focused on the construction of the AuNR@MOF/CCMoid hybrid nanosystem for the detection of metal ions, composed of a gold nanorod (AuNR), surrounded by few layers of metal-organic frameworks (MOFs) and terminated by a curcuminioid (CCMoid) molecules. Due to the presence of the AuNR the fluorescent emission of the nanosystem is intensified by the Surface Enhanced Fluorescence (SEF) effect (2,3) that the AuNR exerts on the chromophore, increasing the detection capacity of these ions. On another hand, the MOF structure plays the role of facilitating the SEF effect and detecting metal ions between their pores, through changes in its fluorescent emission (4). Finally, the detection is expected to be done throught the keto-enol core group of the CCMoid chromophore generating metal complexes as well as throught the funcional groups in the porous of the MOF.

This presentation is directed to explain the different steps of the preparation of the AuNR@MOF/CCMoid nanosystem, starting with the functionalization of the AuNR by a silane spacer agent, the growth of MOF Fe-MIL88-NH_2 surrounding the nanoparticle, generated by layer-by-layer methodology, and finally, the functionalization on the surface of the MOF of the CCMoid chromophore through an amide type bond. Looking for the SEF effect, the distance between the AuNR and the chromophore should be ~12 nm (**Figure 1**). We report the use of two types of spacer agents with different sizes, PEG and MUA, linked to the AuNR and the subsequent functionalization with the MOF and a CCMoid chromophore with non-polar characteristics.

Furthermore, studies will be explain on the changes that can be observed for both the MOF and the chromophore and their combination in their fluorescent emission before and after the addition of metal ions. To check whether the SEF effect that occurs between the AuNR and the chromophore is actually generated, fluorescent emission analyses have been carried out on both, the nanosystem with and without AuNR, that is, AuNR@MOF/CCMoid and MOF/CCMoid .

Keywords: Alzheimer's Disease, MOF, CCMoid, SEF effect, metal ions.

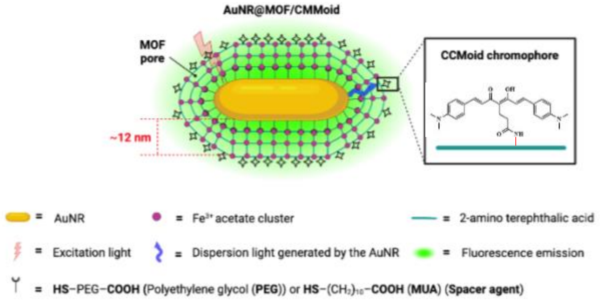

Figure 1: Representation of the AuNR@MOF/CCMoid hybrid nanosystem excitation where the SEF effect generated by AuNR dispersion light is observed and where its effect is facilitated by the MOF structure, to finally increase the fluorescence emission of the chromophore .

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Acknowledgments:

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Development of zeolite-based voltammetric sensor for determination of antipsychotic drug quetiapine

M. Madej [1,*], A. Cader [1], P. Bandyk [1], M. Tomaszewska [1], K. Fendrych [2], J. Kochana [1], B. Baś [2]
[1] Jagiellonian University, Faculty of Chemistry, Gronostajowa 2, 30-387 Kraków, Poland
[2] AGH University of Science and Technology, Faculty of Materials and Ceramics, Adama Mickiewicza 30, 30-059 Kraków, Poland
e-mail: marysia.madej@uj.edu.pl

Abstract:
Over the last years, especially after the outbreak of the COVID-19 pandemic, the significant growth in the number of people suffering from mental illnesses including depression, anxiety, bipolar disorder, schizophrenia, and other psychoses has been observed. Such constant increase reflects into rapid development of the global psychoactive drug market, which was valued at $14.54 billion in 2021, and is estimated to reach $26.04 billion by 2030 [1]. These trends justify the need for the development of quick, cheap and at the same time accurate methods for the determination of antipsychotic drugs. The application of electrochemical sensors creates a unique opportunity to achieve this goal. Moreover, the use of different functional materials for sensors construction, including zeolites and carbon nanomaterials, enables highly sensitive and selective determination of these compounds in various pharmaceutical, biological, and even environmental samples [2,3].

The aim of this work was to develop novel, ecofriendly composite based on zeolite and carbon material for the construction of voltammetric sensor intended for antipsychotic drug quetiapine (QTP) determination. For that purpose, type of zeolite and transition metal ion incorporated into its structure, as well as carbon nanomaterial and polymer binder were selected. The best electrochemical response towards QTP was demonstrated by a glassy carbon electrode (GCE) modified with a composite consisting of clinoptilolite with incorporated Cu^{2+} ions (Cu-Clin) and mesoporous carbon (MC) dispersed in polystyrene matrix (Fig.1). During optimization step, the supporting electrolyte and DPV parameters were selected. For optimized measurement conditions, the analytical parameters of the sensor were estimated. The applicability of the developed method was tested by QTP determination in pharmaceuticals and synthetic urine.

Keywords: electrochemical sensor, voltammetry, zeolites, carbon nanostructures, determination of pharmaceuticals, quetiapine, medical applications.

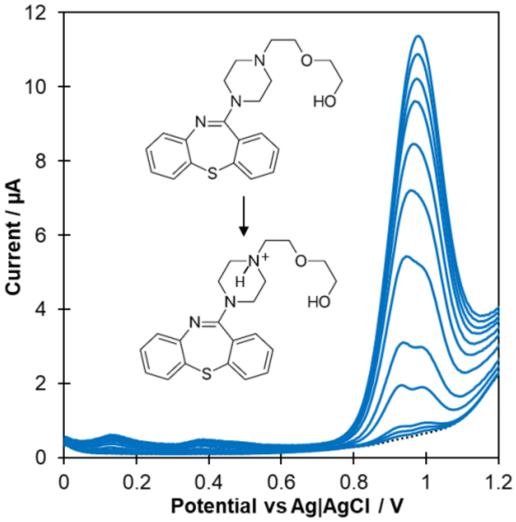

Figure 1: DP voltammograms recorded at Cu-CLIN-MC/GCE in phosphate buffer solution pH 6.0 in the presence of QTP (0.01 – 15 µmol L^{-1}).

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NanoMatEn - Session III. A: Nanotechnology for Environmental Application / Water treatment

Sustainable Technologies for Environment

Marco Piumetti
Department of Applied Science and Technology (DISAT), Politecnico di Torino,
Corso Duca degli Abruzzi 24, 10129 Torino, Italy
*marco.piumetti@polito.it

Abstract:

As is known, carbon dioxide is an important greenhouse gas that comes from the extraction and burning of fossil fuels (such as coal, oil, and natural gas), from wildfires, and from natural processes like volcanic eruptions. However, anthropogenic activities have raised the atmosphere's CO_2 content by 50% in less than 200 years thus causing environmental issues. In order to mitigate the CO_2 emissions many technologies have been proposed and applied. A number of technologies consists in the use of sustainable materials for CO_2 capturing and viable processes for converting CO_2 into valuable products, in the frame of circular economy. The main techniques used for post-combustion CO_2 capture include solid adsorption, solvent scrubbing and membrane separation. However, the solvent scrubbing suffers from high-energy penalty comparing to adsorption processes with solid sorbents. On the other hand, solid adsorption provides favorable advantages including the absence of corrosivity, the low volatility and the low energy penalty. Among the adsorbents used for CO_2 separation processes, zeolites could be promising materials due to their textural and structural properties, polarity, and cation exchange potential. In this contest, the clinoptilolite appears a potential candidate for gas treatment due to its promising CO_2 adsorption capacity at moderate temperature (Piumetti et al., 2020, 2021). Because of its unique chemical and physical properties, clinoptilolite can be effective for several other environmental applications, water/waste water treatment (e.g. heavy metal and organic pollutants removal) (Piumetti et al. 2022), sustainable agriculture (e.g. slow-release fertilization, soil conditioning, remediation, zeoponic plant-growth substrates) VOCs and odor reduction (Colella, 2000). Moreover, many other environmental and energy-related applications can be realized with clinoptilolite. It is worth mentioning that in terms of price, natural zeolites are attractive materials to perform these processes, as they are easily available in nature and do not require expensive treatments. For instance, costs for clinoptilolite typically range from \$100 to \$600 per metric tons, depending on the zeolite content and processing, origin and market prices. In other words, natural zeolites, and in particular clinoptilolite, seem to be promising candidates for many sustainable applications. This lecture will give an overview of the main properties and applications of clinoptilolite, taking in consideration the last scientific reports and experimental results obtained by our research group during the last ten years.

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Graphene oxide and noble metal loaded Ca/Ba/$SrTiO_3$ hybrid photocatalysts for environmental remediation

B. Pal***** and M. Passi
Department of Chemistry and Biochemistry, Thapar Institute of Engineering & Technology,
Patiala-147004, Punjab, India
E-mail: bpal@thapar.edu

Abstract:

Alkaline earth metal titanates ($ATiO_3$, A = Ca, Ba, Sr) from the perovskite family have been largely explored as potent material for semiconductor photocatalysis. These n-type multifunctional perovskites, possess intriguing properties like flexibility in chemical composition, structure, chemical stability, multiple crystal phases, favourable band positions, high oxygen vacancies, strong catalytic activity, ease of synthesis, non-toxicity, low-cost and environmentally benign. However, the quick reconciliation of the photoinduced charge carriers and inefficient usage of visible light energy constrains its quantum efficiency for diverse photocatalytic applications. Surface deposition of metal nanoparticles (Ag, Cu, Fe, etc.) with simultaneous incorporation of a carbonaceous material (such as graphene oxide) is one promising strategy for circumventing the aforementioned limitation. Following that, some ternary visible-light responsive photocatalysts (Ag-$BaTiO_3$/GO, Fe-$SrTiO_3$-GO, Cu-$CaTiO_3$/GO) were prepared and studied their structural and physicochemical properties. Photocatalytic behavior were evaluated by degrading toxic pollutants such as crystal violet dye, antibiotics (ofloxacin, norfloxacin and cefixime) under visible LED light exposure. In contrast with pristine and binary counterparts ($BaTiO_3$-GO, $SrTiO_3$-GO, $CaTiO_3$-GO, Fe-$SrTiO_3$, Cu-$CaTiO_3$ Ag-$BaTiO_3$) as-synthesized ternary nanocomposites exhibited superior degradation efficiency both under UV and visible light irradiation due to better charge separation, excellent electron mobility, and greater surface area of GO that facilitates the charge transfer process. **Figure 1** shows that 1 wt% Ag and Cu loading on $CaTiO_3$ (CTO) highly improved the photocatalytic activity for rhodamine B (RhB) degradation. This work would pave the way for the development of highly efficient and environmentally friendly titanate-based ternary hybrids for environment related applications.

Keywords: Metal titanate photocatalysts, Graphene oxide-titanate composite, Ternary hybrid titanates, Photocatalytic activity under visible light, Perovskite oxide morphology

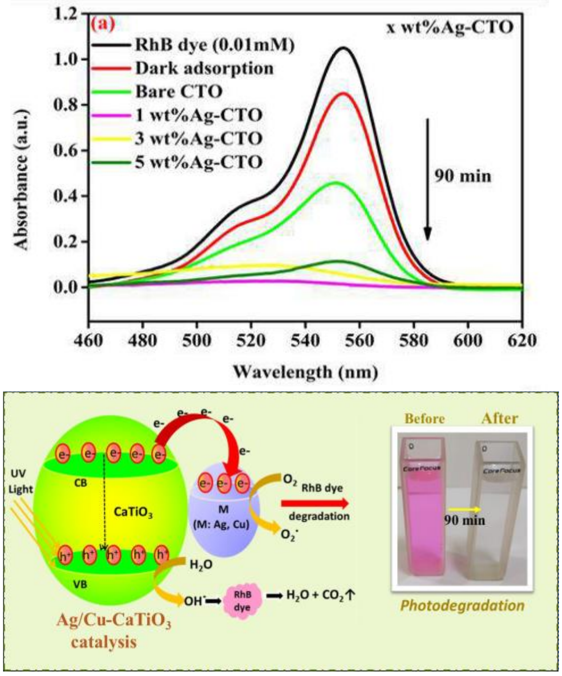

Figure 1: This study reveals the superior co-catalysis effect of Ag and Cu nanoparticles photo deposited on $CaTiO_3$ nanoparticles for the removal of toxic Rhodamine B dye under UV light illumination. An optimal ampont 1wt% Cu/Ag- $CaTiO_3$ nanocomposite photodegraded RhBdye with the highest (98%) effectiveness within 90 min light irradiation as can be evident from the comparative changes in UV absorption spectra and color of RhB dye after its mineralization.

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Low-Temperature Recovery of Deteriorated Ni-Rich Cathode Material Surfaces: $LiNiO_2$ and $LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$ Examples

Fu-Ming Wang*

[1]Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taipei, Taiwan
*Email: mccabe@mail.ntust.edu.tw

Abstract:
Ni-rich cathodes inherit surface residual lithium compounds (SRLCs) for several reasons, such as cation mixing, oxygen vacancies, and the spontaneous reduction of high-Ni valence ions. Consequently, Ni-rich compounds must be treated before use to maximize their performance. This study describes the development of an organic catalyst (OC) that can be directly utilized with a deteriorated Ni-rich cathode. The OC is synthesized from 5,5-dimethylbarbituric acid and polyethylene glycol diacrylate to provide two functions for the deteriorated Ni-rich cathode surface: spontaneous ion exchange and the self-electrochemical oxidation of Ni ions. SRLCs, such as Li_2CO_3 and LiOH, decompose through a transformation reaction from the *tri*oxo to the *di*oxo form of the OC structure. Then this lithiated OC forms an organic artificial cathode electrolyte interface on the cathode surface, which further reduces the effects of chemical crossover on the anode side. It is also believed that the *di*oxo form promotes Ni^{2+} self-oxidation on the surface of Ni-rich cathodes and recovers the original Ni^{3+} valence state by Li^+ re-intercalation. Thus, the capacities of the deteriorated $LiNiO_2$ and $LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$ recover almost to their original values and retain the same excellent cycle performance as that of the fresh compounds.

Keywords: Organic catalyst, Ni-rich, cathode electrolyte interphase, Li_2CO_3, spontaneous ion exchange, self-oxidation

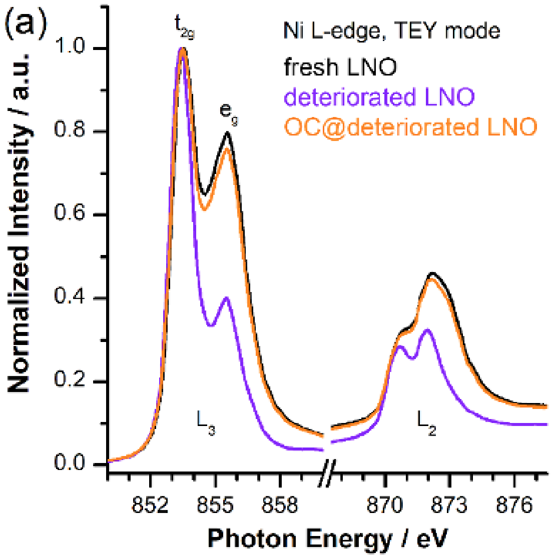

Figure 1 (a) Ni L-edge sXAS spectra taken in TEY mode of fresh LNO (black line), deteriorated LNO (purple line), and OC@deteriorated LNO (orange line).

Nature of Al-Mg electrodeposition using chloride-based molten salt electrolyte system

S. Bhaskaramohan [1*], M. J. N. V. Prasad [2], G. V. D. Jonnalagadda [3], K. Gourishankar [3], S. Swaminathan [3], F. Ebrahimi [4], S. S. V. Tatiparti [1,4]
[1] Dept. of Energy Science & Engineering, Indian Institute of Technology Bombay, Mumbai, India
[2] Dept. of Metall. Engg. & Mater. Sci., Indian Institute of Technology Bombay, Mumbai, India
[3] John F Welch Technology Centre, General Electric India Industrial Pvt. Ltd., Bangalore, India
[4] Materials Science and Engineering Department, University of Florida, Gainesville, USA

Abstract:

Aluminium-magnesium (Al-Mg) alloys are used as hydrogen storage materials, and in industrial applications such as the automotive industry, aviation, household applications, and heat exchangers because of their lightweight, mechanical and chemical properties, corrosion resistance, and aesthetics [1].

Morphology and composition of the alloy play a vital role in the end-use of these alloys. Electrodeposition is a versatile technique for engineering alloys with desired morphology, alloy composition, thickness etc. Electrodeposition of Al and Mg cannot be done using an aqueous electrolyte due to the reduction potentials being negative to the water-splitting potential [2]. Hence, non-aqueous electrolyte systems like molten salts, organometallics are used for Al-Mg deposition.

In the present work, Al-Mg alloys were electrodeposited on commercial copper strips using $AlCl_3$, NaCl, KCl, and $MgCl_2$. Al rod and Al strip were employed as the counter and reference electrode, respectively. Potentiostatic technique was employed for all the depositions at overpotentials (η) of –1.05 to –1.30 V at 180 °C in an Ar-filled glove box maintaining O_2 and H_2O levels at <0.1 ppm and using CHI660E potentiostat. The Al-Mg electrodeposition is categorised into two groups based on steady-state current density results at different η. In both groups, with the increase in η, the morphology of the deposits becomes coarse. The Mg content in the deposits of the 1st group (η: −1.05 V to −1.10 V) is negligible (0.01 to 0.08 atom %), while Mg content increases from 0.26 atom % (η=−1.05 V) to 4.02 atom % (η=−1.30 V) with the increase in η in 2nd group.

The feasibility of obtaining a particular combination of morphology and composition can be addressed by understanding the nature of the Al-Mg electrodeposition. Generally, electrodepositions are industrially classified as “regular”, “anomalous”, “equilibrium”, etc. based on certain trends [2]. For example, the increase in less noble metal (Mg, here) with the increase in η (or current density), observed in the present system, agrees with one of the conditions for “regular” deposition. Further the plot between the compositions (Al/Mg atomic ratios) of deposits and spent electrolytes is analyzed to ascertain the deposition nature. A slight increase in the Al/Mg ratio in the spent electrolyte paralleled with a drastic increase in that of the deposit. This observation suggests the preferential deposition of Al (more noble). Moreover, the composition line (plot between Al/Mg ratios in deposit and electrolyte) always lies above the composition reference line (i.e. line of Al/Mg in deposit = Al/Mg in electrolyte). This confirms the nature of Al-Mg alloy electrodeposition using chloride-based molten salt electrolyte system to be “regular”.

The “regular” nature of Al-Mg electrodeposition under the present conditions results in a maximum of 4.02 atom % of Mg in the deposits which form as adherent films.

Keywords: Morphology, nature of electrodeposition, preferential deposition.

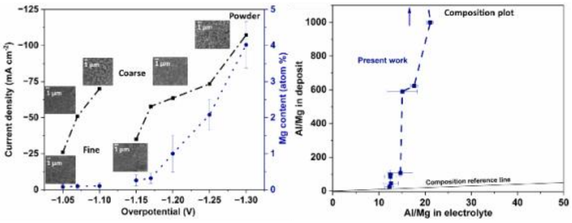

Figure 1: Morphology and composition of the deposit lead to questioning the feasibility of a particular combination of both using this electrolyte system; composition plot.

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Bio-nanomaterials of polymers and fibrillated nanocellulose: preparation, characterization and removal of emerging pollutants from water

Julio Sanchéz*[1], Estefanía Oyarce[1], Karina Roa[1], Andres Boulett[1], Guadalupe Pizarro[2]
[1] Department of Environmental Sciences, Faculty of Chemistry and Biology, University of Santiago. Santiago, Chile. Email: julio.sanchez@usach.cl
[2] Department of Chemistry, Metropolitan Technological University, Santiago, Chile.

Abstract:

Hydrogel materials based on cross-linked polymers and biopolymers, can be chemically modified to improve their physicochemical and thermomechanical properties. Hydrogel materials can be used in various applications such as adsorption of pollutants in aqueous solution [1].

In the present work, hydrogel bio-nanomaterials, are prepared based on carboxylic acids vinyl monomers and fibrillated nanocellulose (NFC) via radical polymerization. NFC was obtained via TEMPO oxidation according to our previous work [2].

During polymerization HEMA co-monomer was used in combination with itaconic acid (AI) and acrylic acid (AA) in the synthesis with different concentrations of NFC to obtain bio-nanomaterials to be used in methylene blue (MB) removal [3].

The bio-nanomaterials were characterized by Fourier transform infrared spectroscopy (FT-IR), scanning electron microscopy (SEM) and thermogravimetric techniques (DSC / TGA). In addition, preliminary sorption studies were performed for the remediation of MB in aqueous solution. The results showed the adequate formation of the hydrogels and a good incorporation of NFC in the matrix, showing yields above 94%. FT-IR characterization shows characteristic signals of its functional groups. The morphology of the hydrogels observed by SEM shows the formation of pores (Figure 1, a)). It can be due to the incorporation of NFC into the carboxylic acid polymer systems (AA and AI). Intermolecular repulsions can be generated between the COO- groups of the NFC and the AA or AI of the polymer matrix, giving porosities on the surface of the hydrogel, increasing the surface area of the interface. In addition, these materials have a good thermal stability which is not affected by the incorporation of NFC. On the other hand, preliminary studies showed a good efficiency and higher removal capacities in the MB sorption from aqueous solution.

Keywords: protein folding, nanoporous sol-gel glasses, silica-based biomaterials, circular dichroism spectroscopy, surface hydration, crowding effects, micropatterning, biomedical applications.

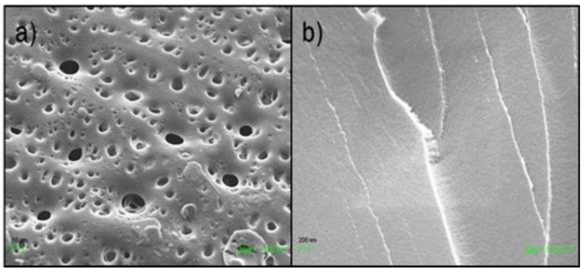

Figure 1: SEM of: a) Surface pore formation of bio-based hydrogel and b) hydrogel of PAA polymer.

Acknowledgements

The authors thank FONDECYT [Grant number 1231498], ANID, PCI [Grant number NSFC190021].

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Investigation of PANI-NSA/$NiFe_2O_4$ Nanocomposite for Efficient Removal of Metal Pollutants from An Aqueous Solution

RN. Kasavo [1], HG. Brink [1]
[1] Department of Chemical Engineering, University of Pretoria, Pretoria, South Africa

Abstract:

Chromium contamination in industrial effluents poses significant environmental concerns due to its high toxicity and mobility. Natural polymers such as polyaniline (PANI) and polypyrrole have been widely used as adsorbents in the removal of heavy metals from wastewater. PANI has gained widespread interest due to its high conductivity, large surface area, ease of synthesis, stability in the environment, and low cost of synthesis. This study explores the potential of a novel nanocomposite, nickel ferrite/polyaniline/2-naphthalene sulfonic (PANI-NSA/$NiFe_2O_4$), in removing heavy metal pollutants from solution. Synthesized with nickel ferrite, polyaniline, and 2-naphthalene sulfonic acid (PANI-NSA) doping, the nanocomposite was characterized using various techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS) and Brunauer-Emmett-Teller (BET) surface area analysis, to evaluate its structural and morphological properties. The formation of tubular-shaped rods with enhanced surface area due to NSA doping was observed from SEM characterization.

Batch studies done using Cr(VI) revealed a remarkable 99.9% removal of Cr(VI) from a 50 mg/L solution with a 25 mg adsorbent dose with maximum adsorption observed at pH 2. Additionally, kinetic studies demonstrated rapid adsorption within the initial 30 minutes, reaching maximum removal within 24 hours.

This study underscores the potential of PANI-NSA/NiFe2O4 nanocomposite as an efficient adsorbent for Cr(VI) removal, presenting a viable approach to mitigate chromium pollution in industrial settings.

Keywords: Adsorption, chromium, nanocomposite, polyaniline, nickel ferrite.

Immobilization of laccase on metal-chitosan nanocomposite and its application in pollutant remediation

H.D. Kyomuhimbo[1], E. M. N. Chirwa[1], U. Feleni[2], and H. G. Brink* [1]
[1]Water Utilisation and Environmental Engineering Division, Department of Chemical Engineering, University of Pretoria, 0002.
[2] Institute for Nanotechnology and Water Sustainability (iNanoWS), College of Science, Engineering and Technology, University of South Africa, Florida Campus, Roodepoort, Johannesburg 1710, South Africa
Email: deon.brink@up.ac.za, u21830658@tuks.co.za

Abstract:
The escalating production of consumer goods, encompassing textiles, paper, dyes, and agrochemicals, has led to a substantial release of pollutants, particularly polyphenols and their derivatives. These compounds are notorious for their high toxicity, carcinogenicity, and resistance to degradation. When released into water bodies, they hinder sunlight penetration, causing detrimental effects on aquatic ecosystems. A myriad of methods, spanning physical, chemical, and biological approaches, have been deployed to address this predicament, often yielding unwanted secondary waste products. Therefore, the quest for environmentally sustainable and economically viable solutions to combat pollutant degradation is of paramount importance. In this context, the textile and paper industries have been notable contributors to environmental contamination, primarily due to the release of organic dyes. Enzymatic degradation, as an eco-friendly approach, has garnered considerable attention. Laccase, a versatile enzyme found in various organisms, exhibits specificity toward a broad spectrum of substrates, including phenols and polyphenols. Laccases are widely employed in pollutant degradation, particularly in dye removal, through one-electron oxidation followed by oxygen reduction. Nevertheless, the inherent drawbacks of laccase, including low stability and limited reusability, necessitate the exploration of immobilization techniques to enhance its performance. In this study, we focus on metal-chitosan nanocomposites as the immobilization matrix for laccase enzymes. Chitosan, a natural polymer found in crustacean shells and fungal cell walls, possesses unique characteristics such as biodegradability, biocompatibility, and adsorption capacity, making it an intriguing alternative to synthetic polymers. The research aims to investigate the application of laccase enzymes immobilized on chitosan-coated nanoparticles. This composite material is expected to offer advantages in terms of enzyme stability, reusability, and pollutant adsorption. Results from batch degradation studies demonstrated a remarkable 30% increase in dye removal when compared to nanocomposite alone as an adsorbent. This finding underscores the potential enhancement in dye removal efficiency promised using laccase in combination with chitosan-coated nanoparticles, showcasing the environmental remediation capabilities of this innovative approach

Keywords: Metal-chitosan nanocomposites, dye degaradation, laccase, immobilization

Highly Sustainable Polyethylene oxide/sodium alginate-based Electrospun Nanofibrous Superabsorbent Mats as Controlled-release Fertilizer Systems

Pooja Chauhan [1*], Bhabani Kumar Satapathy [1]
[1] Department of Materials Science and Engineering, Indian Institute of Technology, Delhi, India

Abstract:

The delivery of agrochemicals (urea, NPK) for the efficient growth of plants, without disturbing the ecological balance of soil-water ecosystem, has become a drastic challenge due to the augmented population level, forfeiture of biodiversity, and contamination of the ecosystem due to artificial/synthetic agrochemicals. In this manner, the fabrication of polymer-based electrospun micro/nanofibrous mats will provide a significant platform for sustainable controlled-release fertilizer systems (CRFs) by endorsing both precision farming and agro-output without alleviating the pollution level of water and soil. Thus, the present research work outlines the development of mechano-functionally engineered NPK-loaded optimized Polyethylene oxide (PEO)/Sodium alginate (SA)-based electrospun nanofibrous constructs as highly potential controlled nutrient release substrates with enhanced and highly sustainable physicomechanical recital for horticultural and agricultural practices. The alteration in morphological, viscoelastic, thermal, microstructural, and mechanical properties of NPK-loaded PEO/SA blended electrospun mats have been explored systemically for evaluating the structural stability. The rate of different studies such as swelling properties, water retention capacity, biodegradability, and nutrient release behavior was significantly studied through both soil and water to ascertain their emerging potential as CRFs for sustainable agriculture. Furthermore, to validate the effectiveness of developed electrospun mats on plant growth, a pot experiment of capsicum (Capsicum frutescens) was conducted in a detailed manner, and the obtained results revealed that the germination rate, plant height, root length, dry and fresh weight of root, and stem length treated with the electrospun mats were found higher than those of treated with the primitive NPK. The obtained outstanding results employ their potential application in the agronomical field for environmental remediation purposes.

Keywords: Agriculture, nitrogen, phosphorus, potassium, polyethylene oxide, sodium alginate, fertilizer, electrospun mats, biodegradable, plants, fertilizer, water, and soil.

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Fluidized bed chemical reactor model for production of syngas in thermo–chemical looping of Ceria

W. Jaroszuk [1], J. Milewski [1,*]

[1] Faculty of Power and Aeronautical Engineering, Warsaw University of Technology, Warsaw, Poland

Abstract:

This paper presents a comprehensive study on the design and analysis of a fluidized bed chemical reactor model for the production of synthesis gas (syngas) via thermo-chemical looping of Ceria. The research focuses on the cyclic reduction and oxidation of metal oxides in high-temperature environments, specifically utilizing Ceria due to its rapid reaction kinetics and high melting point, which facilitates increased reduction process temperatures. The study innovatively employs two fluidized bed reactors operating at significantly different temperatures, necessitating substantial heat transfer between stages. The core of the investigation lies in the simulation of these reactors, aiming to optimize the syngas production with an H2/CO molar ratio conducive to subsequent methanation, thus allowing for efficient storage and transport through existing gas infrastructure. The analysis reveals a theoretical system efficiency of 66%, closely aligning with efficiencies achieved in contemporary coal gasification processes. Furthermore, the study proposes modifications to improve system efficiency, primarily through heat recuperation techniques that counteract the efficiency drop caused by inadequate heat recovery. This work contributes significantly to the field of renewable energy sources by providing a viable method for the efficient production and storage of green methane, offering a detailed exploration of the potential of chemical looping processes in modern energy systems.

Keywords: chemical looping, Ceria, solar fuels, fluidized bed reactors, renewable energy, syngas production, heat recuperation, green methane

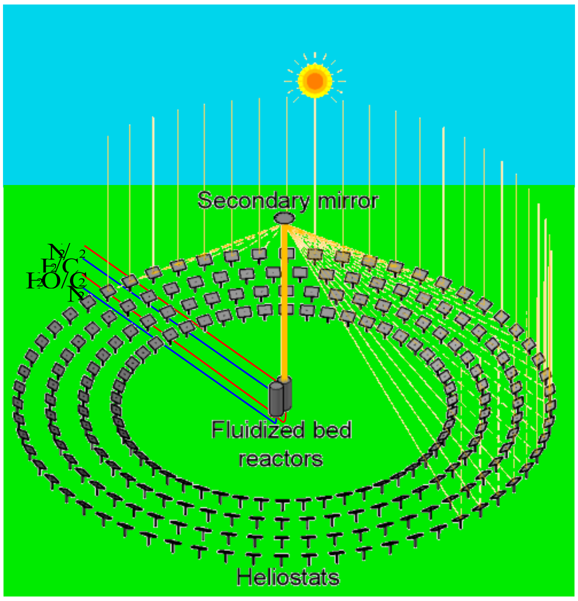

Figure 1: Possible configuration of the solar fuels production plant utilizing fluidized bed reactors and heliostats (adopted from [1])

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Posters Abstracts

Low temperature synthesis of crystalline GaN from a mixture of Li and Ga under N_2 atmosphere

Youting Song

Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing , 100190， China

Abstract:

The crystalline GaN has been synthesized by using Li/Ga mixture (different Li/Ga molar ratios ） as starting materials at 415-575℃ and 1-2 atm of N_2. The synthetized GaN is characterized by XRD, SEM, Raman spectra, and PL spectra, which shows that the crystalline GaN is of good quality. Meanwhile, the formation mechanism of GaN was investigated. Li first reacts with N_2 to produce Li_3N, and then Ga combines simultaneously with Li and N in Li_3N to produce GaLi and GaN, which makes Gibbs free energy of the reaction (Li_3N + Ga = GaN + GaLi) negative, in agreement with our experimental results. In addition, the releasing heat in the nitriding process of lithium raises the temperature of the whole system, and thus enhances the reaction rate of Li_3N and Ga. Thus, the synthesis of crystalline GaN embodies the double contributions from kinetics and thermodynamics of whole system.

Keywords: crystalline GaN, the formation mechanism of GaN, XRD, SEM, Raman spectra, and PL spectra, kinetics and thermodynamics of whole system, wide bandgap semiconductor, short wavelength optoelectronics and high-power and high-frequency electronics applications.

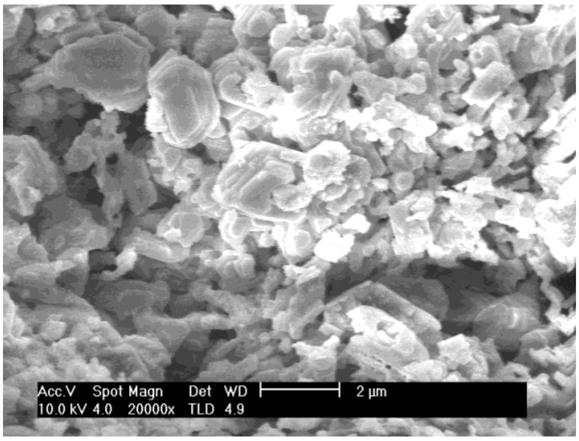

Figure 1: Figure illustrating crystalline GaN synthetized from a mixture of Li and Ga under N_2 atmosphere at 575℃.

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Green Route to Copper Nanoparticles on Natural Zeolite Clinoptilolite: Synthesis and Characterization

M. Lallukka [1,*], F. Gattucci [1], M. Piumetti [1], M.Miola [1]
[1] Department of Applied Science and Technology, Politecnico di Torino, Turin, Italy

Abstract:

Natural zeolite clinoptilolite and copper nanoparticles (CuNPs) hold immense potential for diverse applications owing to their unique physical and chemical properties. Zeolites, such as clinoptilolite, with their high surface area and cation exchange capacity, serve as excellent hosts for various catalytic processes [1]. Meanwhile, copper nanoparticles exhibit exceptional catalytic and antimicrobial properties, making them valuable in combating bacterial infections [2].

In this study, we present a green synthesis approach for the production of copper nanoparticles on natural zeolite clinoptilolite using tannic acid as reducing agent. Different copper salts are evaluated as precursors for the nanoparticles. This method offers an eco-friendly alternative to traditional synthesis routes, preventing the use of toxic reducing agents, organic solvents, and high temperatures [3]. Structural and compositional analyses, including X-ray diffraction (XRD) and scanning electron microscopy equipped with energy dispersive spectroscopy (FESEM-EDS), confirmed the successful reduction of Cu^{2+} ions to metallic copper on clinoptilolite powder. The preliminary results demonstrate the formation of Cu-nanoparticles, showcasing the potential of this material for antimicrobial applications and photocatalytic activities.

This study was carried out within the MICS (Made in Italy – Circular and Sustainable) Extended Partnership and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.3 – D.D. 1551.11-10-2022, PE00000004). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

Keywords: clinoptilolite, tannic acid, copper nanoparticles

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Control on the formation of colloidal crystals of uniform populations of cubic maghemite nanoparticles with tunable size and surface chemistry

A. Shahmanesh [1,*], A. Ngo [1], I. Lisiecki [1]
[1] De la Molécule aux Nano-Objets: Réactivité, Interactions Spectroscopies, MONARIS, Sorbonne University, Paris, France

Abstract:

Iron oxide nanoparticles with controlled size, shape, and magnetic properties have attracted considerable attention due to their unique magnetic properties and potential applications in various fields, including biomedicine, biosensing, and energy storage[1]. The thermal decomposition organometallic precursors in the presence of surfactants has been widely studied to synthesize iron oxide nanoparticles with controlled size and shape [2]. There are different parameters such as reaction temperature, reaction time, solvent, concentration of the reactants, and the ligands, which can influence the size, shape, and properties of the resulting nanoparticles [3]. Besides the development of strategies for cubic IONPs synthesis with tunable size and shape, the control of their interaction with various environments is of great importance and required to adjust the surface chemistry. This is the case for example to improve: (1) the dispersion of the NPs in a given solvent; (2) their surface activity; (3) their biocompatibility. In this study we investigated the synthesis of uniform cubic maghemite NPs with two different coating agents, dodecanoic acid (C12) and oleic acid (C18). This study has been done to form colloidal crystals from cubic maghemite and verify their collective properties. For these two types of ligands, the synthesis conditions are adjusted to promote three sizes of NPs, identical from one ligand to another. TEM and HRTEM images prove that the IONPs are formed in cubic shape with maghemite structure, which is approved by XRD diffraction analysis. Colloidal crystals have been formed by adding gradually bad solvent inside the well-dispersed solution. Figure 1 shows the TEM and HRTEM of cubic IONPs and SEM of preliminary results of colloidal crystals.

Keywords: Maghemite, Cubic shape, Thermal decomposition, Tunable surface chemistry, Magnetism.

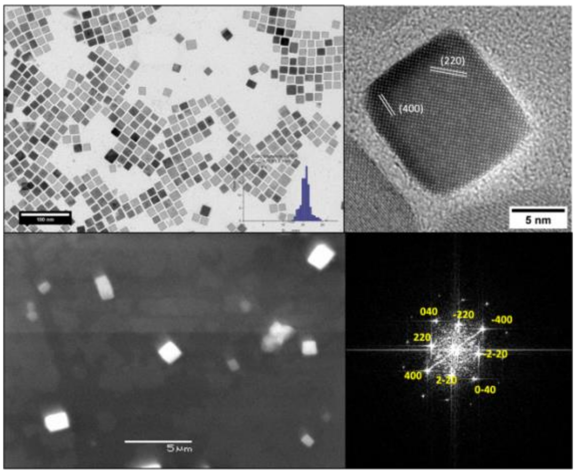

Figure 1: TEM and HRTEM images of cubic iron oxide nanoparticles synthesized from thermal decomposition of iron oleate. From the HRTEM image, as the cubes consist of low energy [100] axes, the lattice fringes corresponding (220) and (400) planes are determined. SEM image represent the cubic and rectangular colloidal crystals.

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Production of biopolymers from pumpkin shell waste and its effect on filtration and rheological properties of water-based drilling mud- toward sustainable drilling

F. Faraji ^{1*}, S. Baloochzadeh ^{2}, M. Abdulqadir^{1}
[1] Department Engineering, Teesside University, Middlesbrough, UK
[2] Department Engineering, Sunderland University, Sunderland, UK

Abstract:

Meeting global energy demand in a sustainable way requires cost-effective, environmentally friendly, and biodegradable water-based drilling fluid (WBDF) that can be used for sustainable drilling. Nevertheless, the fluid loss into the formation during the drilling is a major issue of WBDF. Various chemical-based fluid loss additives in the industry have been used to control WBDF loss into formation. However, using chemical additives poses a risk to the environment, pollutes water reserves, and threatens the ecosystem. In this study, based on pumpkin peel waste (PPW), a biopolymer additive was introduced to enhance WBDF filtration and rheological properties. The sample of the PPW was dried, crushed and grounded using a ball mill into two very fine (10µm) and fine (75µm) particle sizes. Then, the samples were added to the conventional WBDF at optimum weight concentrations of 3wt%, and the rheological and filtration properties of the proposed WBDF were investigated using industry API filtration and rheological tests. Furthermore, major elemental analyses of the samples were carried out using an energy-dispersive x-ray spectrometer (EDX), fourier transform infrared (FTIR) and scanning electron microscopy (SEM). The results of filtration test indicate adding 3wt% of very fine (10µm) and fine (75µm) PPW biopolymer reduced fluid loss by 38.8% (from 18cc to 11cc) and 33.3% (from 18cc to 11cc) for the duration of 25 minutes. This also resulted in formation of thin filter cakes of 3mm and 2.5mm when very fine and fine particles of PPW were added to the mud, respectively.

The rheological property tests indicated that using PPW biopolymer in WBDF increases mud density slightly by 1.12%. Moreover, the apparent viscosity of the reference WBDF was increased by 50% (from 4cp to 8cp) and 35% (from 10cp to 13.5cp) adding 3wt% PPW of 10µm and 75µm, respectively. In addition, adding same concentration of very fine and fine particles of PPW would increase the yield point of the WBDF by 33% (from 12 to 18 Ib/100ft2) and 7.7% (from 12 to 13 Ib/100ft2).

The proposed biopolymer not only has environmental benefits but also offers technical enhancements to drilling fluid performance, particularly in filter cake formation where they contribute to improved sealing capabilities and fluid loss control.

Keywords: Drilling fluid, biopolymers, waste pumpkin shell (PPW), biodegradable material, sustainable material.

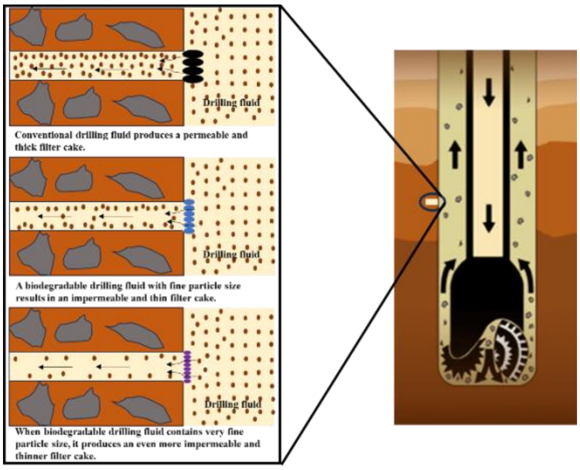

Figure 1: Figure illustrates the fundamental mechanism of drilling fluid operation. The mechanism shows that conventional WBDF penetrates to the formation considerably. While adding the biodegradable polymers produced from pumpkin shell waste reduce the fluid loss substantially.

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Preparation of high-porosity thin metal films using high-angle ion sputtering and high-fluence high-energy ion bombardment

G. Ceccio [1*], J. Vacik [1], V. Lavrentiev [1], R. Miksova [1], P. Pleskunov [2]
[1] Nuclear Physics Institute of Czech Academy of Science, 250 68 Rez, Czech Republic
[2]V Holesovickach 2, 180 00, Prague

Abstract:
A new unconventional method of preparing metal nanostructures with a high surface density of nanoparticles of various shapes by ion sputtering (IBS) using a glancing angle configuration (GLAD) and subsequent heavy ion irradiation was tested. The prepared and modified nanostructures were characterized using ion beam analytical methods (Rutherford Backscattering Spectroscopy on milli-beam and Scanning Transmission Ion Microscopy on micro-beam of the Tandetron accelerator) and microscopic techniques (Atomic Force Microscopy and Scanning Electron Microscopy). Bombardment of metal films with heavy ions (Ar^+) of keV energy has been shown to lead to significant changes in their porosity and electrical and optical properties. In principle, nanostructures whose properties can be controlled by ion bombardment can be suitable for various applications. This study showed that the IBS method with GLAD configuration is a promising way to prepare highly porous metal nanostructures with high optical absorbance. Such materials can be used, for example, for gas sensors.

Keywords: Ion Beam Sputtering, Metal Nanostructure, Surface Modification, Optical Absorbance, Sheet Resistance

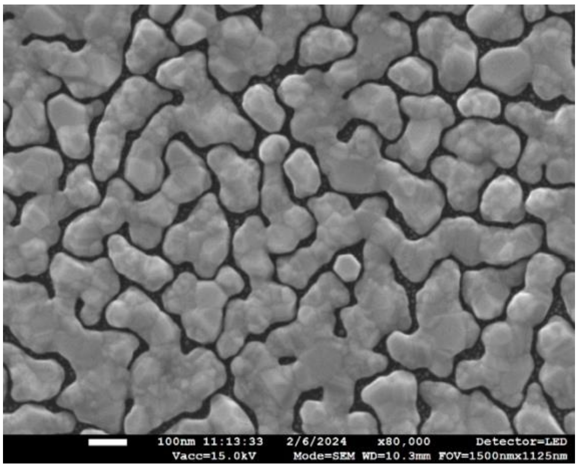

Figure 1: A thin silver film prepared by ion beam sputtering using 20 kev Ar^+ ions in a GLAD configuration, and subsequent ion bombardment by 5 kev Ar^+ with a fluence of 10^{17} at. cm^{-2}.

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This work was supported by the Czech Science Foundation (GACR) under the project 23-05002S. The measurements were carried out at the 'CANAM' infrastructure of the NPI CAS Rez.

Reversible thermal conductivity switching of Mg-based thin films controlled by hydro-/dehydrogenation reactions

T. Yagi[1,2*], H. Yagi[2], K. Sugimoto[2], K. Nakano[2], Y. Yamashita[1,2], T. Shiga[1], M. Kashiwagi[2],
S. Takeya[1], Y. Oguchi[2], F. Iesari[3], T. Okajima[3], N. Taketoshi[1,2], Y. Shigesato[2]
[1] National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan
[2] Graduate School of Science & Engineering, Aoyama Gakuin University, Sagamihara, Japan
[3] Aichi Synchrotron Radiation Center, Seto, Japan

Abstract:

Artificial devices that can freely control thermal energy are one of the crucial goals in thermal engineering1). A thermal conductivity switch is a simple concept that controls heat flow on and off by contrasting thermal conductivity due to some physical phenomenon. Here we propose Mg-based switching mirrors as a new concept of thermal conductivity switch driven by a chemical reaction. The switching mirror can reversibly change between a transparent (hydride) state and a mirror (metal) state through hydro-/dehydrogenation. Since the mirror state is a metal, a high thermal conductivity owing to high free electron density is expected. In this study, reversible behavior of thermal conductivity switching for three kinds of Mg-based films: Ni-Mg, Y-Mg, and Co-Mg was investigated using in-situ time-domain thermoreflectance (TDTR) measurement.

Schematic structure of samples is shown in Fig.1(a). The Mg-based films with nominal thickness of 200 nm or 300 nm were deposited on a Mo transducer (100 nm in thickness). The Mg-based film was covered by a 5nm-thick Pd layer as a catalyst of hydrogenation and dehydrogenation. Those layered structures were fabricated on a quartz glass substrate by means of dc magnetron sputtering. Each Mg-based film contained 14 at%Ni, 60 at%Y, and 28 at%Co, respectively.

For the TDTR measurements, the Mo transducer was heated by a pump laser pulse (0.5 ps in pulse duration, 1550 nm in wavelength, 20 MHz in frequency). Transient temperature change was measured using a probe laser pulse (0.5 ps, 775 nm, 20 MHz). The typical TDTR signals are shown in Fig.1 (b). The hydrogenation and de-hydrogenation of the Mg-based films were controlled using a dilute H_2 gas and air, respectively.

Figure 2 shows reversibility of thermal conductivity switching for three kinds of the Mg-based films. The Ni-Mg film2) shows the highest contrast of thermal conductivity: 14 W m^{-1} K^{-1} in the dehydrogenated state and 1.0 W m^{-1} K^{-1} in the hydrogenated state. The higher thermal conductivities at the dehydrogenated states are agreement with free electron contribution based upon Wiedemann–Franz law.

This work was supported by JSPS KAKENHI (23H01362, 23H01360), JST FOREST (JPMJFR222G), and JST CREST (JPMJCR1861).

Keywords: thermal conductivity switching, Mg-based films, time-domain thermoreflectance, hydrogenation, dehydrogenation, thermal engineering application.

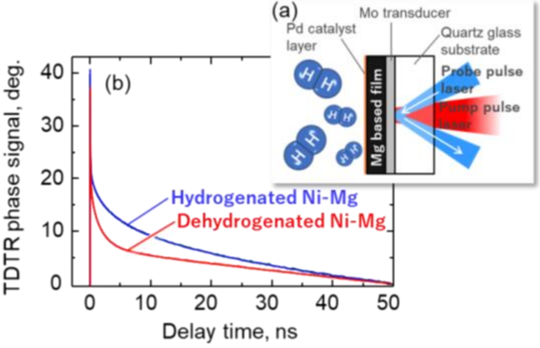

Figure 1: (a) Schematic illustration of the Mg-based film sample and TDTR measurement setup. (b) Typical transient TDTR signals for the hydrogenated and dehydrogenated Ni-Mg film[2].

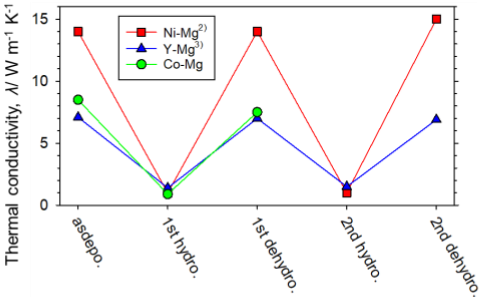

Figure 2: Switching behaviour of thermal conductivity for Ni-Mg2), Y-Mg3), and Co-Mg films through hydrogenation and dehydrogenation.

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Improvement of Photosensor Properties of ZnO Films by Using the Features of Nanostructured State

S. Dukarov[1], S. Petrushenko*[1,2], K. Adach[2], M. Fijalkowski*[2], A Fedonenko[1], V. Sukhov[1]
[1] V.N. Karazin Kharkiv National University, Kharkiv, Ukraine
[2] Institute for Nanomaterials, Advanced Technologies and Innovation, Technical University of Liberec, Liberec, Czech Republic

Abstract:

The development of sensor technologies requires simultaneous solution of a number of problems. Thus, in addition to increasing sensitivity, reliability, speed of response and reducing the cost of detectors, in many cases it is still relevant to develop physical understanding of the mechanisms of sensor operation.

UV sensors occupy an important place in modern technologies and involve dual-use. A promising UV sensor material is ZnO films, which combine environmental friendliness, resistance to environmental conditions and can be produced using very affordable scalable technologies such as SILAR. Due to the fact that ZnO films are usually composed of scattered particles, these detectors are suitable for flexible technologies. In turn, flexible technologies are a rapidly growing strain of modern industry.

However, UV detectors based on ZnO are still inferior to known sensors. Also, the mechanisms of photosensitivity of ZnO particles are not fully understood today. It is reasonable to expect that the use of size effects, which can be observed both for separate nanoparticles and nanocomposites, may be a promising way not only to improve the technological parameters of sensors, but also to deepen the physical understanding of photosensitivity mechanisms.

The work is devoted to the study of photosensitivity of ZnO films with different microstructure. We studies two series of films. The films of the first series were obtained using a rather complicated method of hydrothermal synthesis using by microwaves chemical reactor. These films consist of single-crystalline particles of about 50 nm in size. The films of the second series were obtained using the affordable, scalable SILAR room temperature wet synthesis technique. They are an example of nanocomposite materials and consist of particles of several hundred nanometres in size. However, these particles are polycrystalline and are themselves composed of grains with a most likely size of 10 nm.

Two detector designs were studied: horizontal detectors, in which current carriers must overcome particle boundaries when travelling between electrodes, and vertical detectors, in which current carriers move mainly inside a single particle and leave it only after reaching the electrodes. It is found that in all cases ZnO films are sensitive to UV radiation even when a biasing of less than 0.5 V is used. This makes them a convenient object for nanostructured systems, in which the use of large voltages is associated with some difficulties.

Comparison of detectors of vertical and horizontal types allowed us to obtain some information about the mechanisms of photosensitivity. Thus, it is shown that in detectors of horizontal type the dependence of photocurrent on time is confidently described by a biexponential function. The time constants of the first and second terms of this function differ approximately three times. At the same time in vertical detectors this dependence has an exponential character, i.e. the equation describing the dependence of photocurrent on time has only one term. This indicates that the photosensitivity of ZnO films is provided by two mechanisms. The first one is caused by the external boundaries of the particles that build the films. It plays an important role in horizontal detectors but has a small contribution in vertical type detectors. But it has a small contribution in photosensitivity of vertical type detectors. The second mechanism is due to carrier traps located deep within the particles. This mechanism appears in both types of detectors.

Nanocomposite films obtained by the cheaper SILAR method were found to have significantly higher photosensitivity than films deposited by the hydrothermal method. This effect is attributed to the class of inner size effects. It is explained by the shallower depth of traps concentrated at the crystal grain boundaries compared to those concentrated on the particle surface. Thus, it is shown that due to the nanostructured state, the use of the SILAR method allows not only to reduce the cost of detectors, but also to increase their sensitivity.

Keywords: zinc oxide, photosensitivity, nanosensors, single-crystalline particles, nancomposite materials

Ti/TiSi/TiSiN/TiSiCN protective multilayered structures used for Industrial woodworking applications obtained by cathodic arc evaporation

Lidia R. Constantin[1] , Anca C.Parau[1], Mihaela Dinu[1], Iulian Pana[1], Catalin Vitelaru[1], Diana Maria Vranceanu [2,3], Alina Vladescu (Dragomir)[1]
[1]National Institute of Research and Development for Optoelectronics - INOE 2000, Department for Advanced Surface Processing and Analysis by Vacuum Technologies, 409 Atomistilor St., Magurele, RO77125, Romania
[2]Drugon International SRL, 2 Tractorului, Constanta, Romania
[3]University Politehnica of Bucharest, Faculty of Materials Science and Engineering, 313 Spl. Independentei, RO60042, Bucharest, Romania

Abstract:

The wood processing industry's expanding significance has brought in dramatic improvements of the machines and devices, within the path to full mechanization of the production process.[1]. The most challenges in wood machining emerge from differences in physical and chemical structures of the involved materials, wood and metals. Although wood encompasses a great machinability permitting tall cutting and feed speed, the water content makes it very corrosive for the tools that are used [2]

TiCN coatings are widely recognized as hard coatings utilized in industrial applications, because of their toughness and ability to resist oxidation, along with a low friction coefficient when sliding on steel and alumina in air. Nevertheless, these coatings exhibit inadequate resistance to corrosion and limited resistance to tribocorrosion. Therefore, one potential method for enhancing these two characteristics is by incorporating silicon. The formation of silicon nitride phase can occur, potentially resulting in enhanced resistance to corrosion and tribocorrosion, thanks to the nonmiscible nanocrystalline and amorphous phases.

The multilayered coatings-based Ti/TiSi/TiSiN/TiSiCN, were deposited by cathodic arc evaporation technique. The reactive gas mixture of C_2H_2 and N_2 was used as a control parameter to obtain coatings with different C/N ratios, for this reason the N_2 mass flow rates were successively increased (80/110 sccm) in the detriment of C_2H_2 mass flow rates (110/20 sccm), while the rest of the parameters used for each deposition run were maintained (2x 10-3 Pa residual pressure, 6 x10^{-2} Pa working pressure, -200 V substrate bias, 90 A arc current, 40 min. deposition time and a final thickness of ~ 2 µm). Morphological, microstructural and mechanical analyses were conducted, including elemental composition, surface morphology, X-ray diffraction, which were performed before and after corrosion and tribocorrosion process evaluation. From microscopical point of view, visible evidence of a possible deterioration and the presence of corrosion products were observed as a function of steel substrates and their composition.

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 (INOE) and COFUND-M-ERANET-3-HardCoat-2, no. 312/2022 (Drugon), 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, cathodic arc evaporation

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Radial lower chuck design using metamaterials and prediction of surface roughness in PBF

K. W. Kim [1*], J. W. Lee [1], S. H. Park [1], S. Y. Lee [1], S. Y. Gu [1], D. H. Kim [1], J. H. Sung [1]
[1] Daegyeong Application Technology Group, Korea Institute of Industrial Technology, Daegu, Repubilic of Korea

Abstract:

Recently, 3D printing technology has been growing with rapid advancements in materials, powders, design, analysis, post-processing, and equipment. In particular, the power bed fusion (PBF) method is the most widely used because it has the advantage of manufacturing products with high precision and excellent surface quality. The posture of the product is determined by considering the buildability of the parts. Existing software determines the buildability by considering only the angle from the horizontal axis and creates support based on that. In other words, simply setting the standard for the overhang angle to a specific value has the disadvantage of applying excessive support. To overcome this, this study developed a program that can take into account the buildability of the current floor by considering the buildability of the previous floor. Based on this, we also developed a program that can predict the surface roughness of parts. The performance of the developed program was verified for lower chucks used in semiconductor post-processing. In the wafer inspection process, improving temperature uniformity in the lower chuck can improve inspection speed. When manufacturing a lower chuck with 3D printing, a structure advantageous for improving temperature uniformity can be created by creating a radial flow path. Additionally, by inserting a metamaterial where the thermo-electric module(TEM) is located, heat transfer performance in that area can be improved (Figure 1). Therefore, the buildability was inspected using a program developed for the lower chuck to which metamaterial was applied, and the surface roughness was also predicted (Figure 2).

Keywords: 3D printing, powder bed fusion, metamaterials, buildability, surface roughness.

Acknowledgement:

This research was supported the Korea Institute of Industrial Techonlogy (Project Number: JB240003).

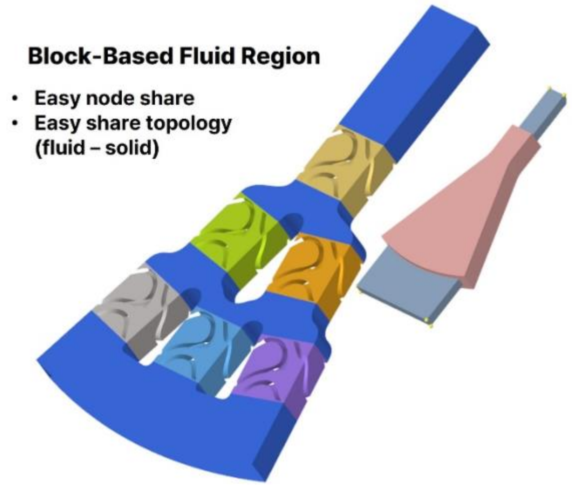

Figure 1: 1/9 model of lower chuck applying double-wall Gyroid sheet-TPMS metamaterial

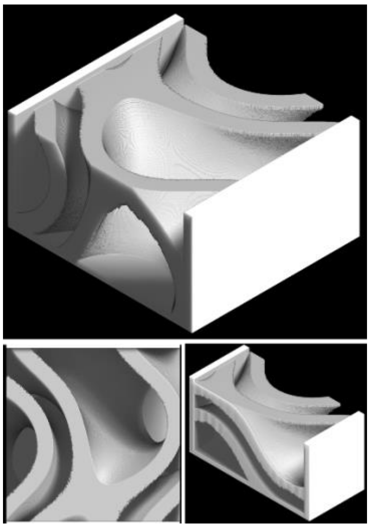

Figure 2: Prediction of buildability and scanning data of lower chuck

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New route to synthesis nanomaterial of lead sulfide (galena) films from bis(alkylxanthato) lead(II) precursors

Yasser T Alharbi [1], David Lewis [2]
[1] Department of General Studies, Royal Commission for Jubail and Yanbu, Yanbu Industrial College, Yanbu, Saudi Arabia
[2] Department of Materials, The University of Manchester, Oxford Road, Manchester, M13 9PL, United Kingdom.

Abstract:

Lead sulfide films were produced from a series of bis(alkylxanthato) lead(II) complexes by a spray-coat-pyrolysis method. We confirmed that the resulting nanomaterial was influenced by the preparation technique and type of ligand.. The sizes were decreased in bis(alkylxanthato) lead(II) precursors when the alkyl chain increased. All films were characterized by powder X-ray diffraction (p-XRD), Raman spectroscopy, secondary electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX).

Keywords: spray-coat-pyrolysis method, precursors, bis(alkylxanthato) lead(II) complexes, circular dichroism spectroscopy, surface hydration, crowding effects, micropatterning, biomedical applications.

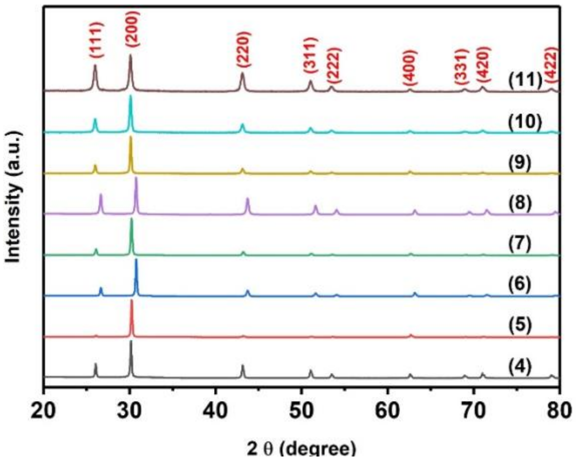

Figure 1: Figure The p-XRD patterns of PbS (ICDD. No. 01-078-1058) deposited by spray-coat-pyrolysis method from the complexes 4 to 11 at 200 °C for 1h, under nitrogen.

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Electrospun Polycaprolactone Nanofibers: Influence of Fiber Diameter on Bacterial Biofilm Formation and Bacterial Cell Retention

S. Lencova[1 *], M. Stindlova[1], V. Peroutka[1], V. Jencova[2], K. Havlickova[2], D. Lukas[2], K. Demnerova[1]
[1] Department of Biochemistry and Microbiology, University of Chemistry and Technology, Prague , Czech Republic
[2] Department of Chemistry, Faculty of Science, Humanities and Education, Technical University of Liberec, Liberec, Czech Republic

Abstract:

Electrospun nanofibrous materials are widely applied in many spheres of human life, including medicine, the food industry, and biotechnology. In the current research, attention is focused on their microbiological safety as microorganisms can attach most of commonly used nanomaterials. Microbiological safety can be ensured either by the functionalization of the nanofibers with antimicrobial substances or by a proper modification of their morphology. Several papers reported that fiber diameter and surface density significantly affect the interactions between nanomaterials and microorganisms. In this study, we evaluated and statistically analyzed the influence of polycaprolactone (PCL) fiber diameter on biofilm formation and retention of four strains of model bacteria *Escherichia coli* and *Staphylococcus aureus*, representing opportunistic pathogens relevant to medicine, food industry, and biotechnology. We prepared and tested two PCL nanomaterials, PCL45 and PCL80. Regarding biofilm formation, PCL (having thin fibers) was colonized less than polystyrene, the control material. Fiber diameter did not influence the biofilm formation of three of the tested strains ($p > 0.05$), while influenced the biofilm formation of one of the tested *E. coli* strains ($p < 0.05$). It was observed that fiber diameter impacts the structure and location preferences of biofilm formation. Furthermore, the ability of the tested PCLs to retain bacterial cells was tested. Fiber diameter significantly ($p < 0.01$) influenced the retention capacity. PCL45 showed higher retention in general; PCL45 retained staphylococcal cells completely, while *E. coli* was retained much less. Our results confirm the prediction that fiber morphology may influence microbial interactions and emphasize the need for further testing.

Keywords: electrospinning, fibers, biofilm formation, filtration, retention, fiber diameter.

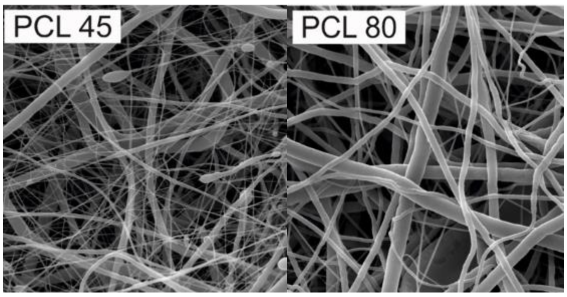

Figure 1: SEM images of the tested PCL materials.

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Acknowledgements:

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Antibacterial Activity of Electrospun Fibers with Graphene

V. Peroutka [1*], S. Lencova [1,2], C. G. Aneziris [3], E. Storti [3], K. Demnerova [1] and O. Jankovsky [2]
[1] Department of Biochemistry and Microbiology, University of Chemistry and Technology, Prague , Czech Republic
[2] Department of Inorganic Chemistry, University of Chemistry and Technology Prague, Prague, Czech Republic
[3]Institute of Ceramics, Refractories and Composite Materials, TU Bergakademie Freiberg, Freiberg, Germany

Abstract:

Graphene materials have attracted huge attention from both basic and applied research over the last decades as they dispone unique properties and ability to improve the physical and chemical characteristics of other materials. Currently, nanofibers containing graphene and its derivates are considered a promising strategy of enhancing conventional materials properties. Usually, graphene and graphene oxide (GO) are used for the production of functionalized fibers. Graphene nanoplatelets (GNPs) prepared by milling of graphite represent another interesting form of graphene. Because of their small size, they can be incorporated into the thin fibers more easily than graphene or GO. Several studies reported the successful synthesis of electrospun fibers containing GNPs. However, the preparation of homogeneous, well-characterized, and production- and cost-effective GNP-containing fibers remains difficult. In this study, polyvinyl-pyrrolidone (PVP) fibers containing small graphene particles (graphene with surface area 750 m^2/g) were electrospuned and characterized in terms of their physico-chemical and antibacterial properties. The set of materials differing in the content of PVP, graphene, and GNPs were prepared. The graphene concentration was increased up to 20 wt% in the fiber product. GNPs were successfully embedded within the fibers. Graphene concentration did not influence the dynamic viscosity of the suspension or fiber diameter. Further, the antimicrobial activity of graphene-containing fibers was tested with two model bacterial strains, *Staphylococcus aureus* CCM 3953 and *Escherichia coli* CCM 3954. Both pure graphene, used as a reference, and graphene-containing fibers inhibited bacterial growth similarly. The higher inhibition (up to 81 %) was observed for coccal cells of the gram-positive bacterium *S. aureus*, while lower effectivity (up to 13 %) was determined for the gram-negative bacterium *E. coli*.

Keywords: graphene, electrospinning, fibers, antibacterial activity.

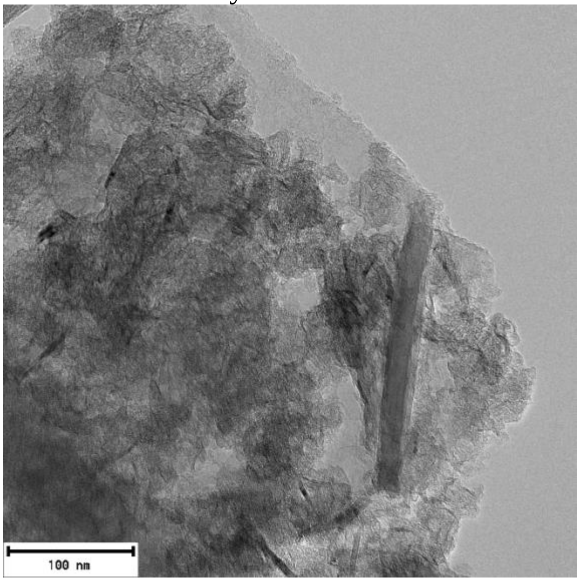

Figure 1: TEM micrograph of graphene with 750 m^2/g specific surface, which was used in the electrospinning suspension.

Acknowledgements:

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Effect of nanofibrous materials with different morphology on bacterial and yeast biofilm formation

M. Stindlova[1 *], S. Lencova[1], K. Zdenkova[1], V. Jencova[2], E. Kuzelova Kostakova[2], S. Hauzerova[2], D. Lukas[2], K. Demnerova[1]
[1] Department of Biochemistry and Microbiology, University of Chemistry and Technology, Prague, Czech Republic
[2] Department of Chemistry, Faculty of Science, Humanities and Education, Technical University of Liberec, Liberec, Czech Republic

Abstract:

Nowadays, nanofibrous materials are commonly applied as wound dressings or implant coating thanks to their beneficial features like porosity, surface-to-volume ratio, or tissue similarity. However, they are also suitable for microbial growth and can negatively contribute to infections. To create biologically active surfaces but avoid the use of antimicrobial substances, fibre surfaces can be further modified. In this study, we tested two polycaprolactone (PCL) nanomaterials of different mean fibre diameters (PCL45 and PCL80) with smooth or structured fibre surface for the biofilm formation of three bacteria (*Staphylococcus aureus* (CCM 3953 and MW2), *Escherichia coli* (CCM 3954 and CCM 4517), *Salmonella enterica* subsp. *enteritidis* (CCM 4420 and CCM 7189)) and two yeasts (*Candida albicans* (CCM 8215 and CCM 8261), *Saccharomyces cerevisiae* (CCM 8191 and CCM 8381)). Tested PCL nanomaterials were significantly less colonised than control polystyrene microtiter plates ($p < 0.05$). Regarding bacterial biofilms, PCL influence was strain-specific and various effects were observed in all three bacteria. In the case of yeast biofilms, the growth was almost uniformly diminished for more than one order of magnitude and, generally, fewer cells grew on PCL45 than on PCL80 with no regard for the structure on the fibre surface. Overall, our results suggest that the tested nanomaterials are more efficient against yeasts than bacteria.

Keywords: nanofibrous materials, structured nanomaterials, biofilm formation, bacterial and yeast infections.

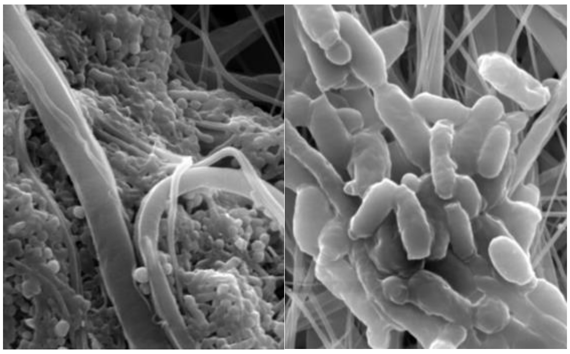

Figure 1: SEM images illustrating the growth of bacterial (*S. aureus*, left) and yeast (*C. albicans*, right) biofilm on the tested PCL45 material.

References:

1. Lencova, S., Svarcova, V., Stiborova, H., Demnerova, K., Jencova, V., Hozdova, K., Zdenkova, K. (2021), Bacterial Biofilms on Polyamide Nanofibers: Factors Influencing Biofilm Formation and Evaluation, ACS Appl. Mater. and Interfaces, 13, 2277-2288.

Acknowledgements:

The research was supported by Czech Science Foundation Grant No. **23-05154S**.

Bacterial biofilm degradation measurement using biophysical parameters

Katarzyna Gałczyńska[1,3], Aneta Węgierek-Ciuk[1], Sławomir Wąsik[4], Maria Baczewska[2], Arkadiusz Kuś[2], Małgorzata Kujawińska[2], Michał Arabski[1,3]

[1] Division of Medical Biology, Jan Kochanowski University, Uniwersytecka Street 7, Kielce 25-406 (Poland)
[2] Institute of Micromechanics and Photonics, Warsaw University of Technology (Poland)
[3] Central Office of Measures, Warsaw (Poland)
[4] Division of Physics, Jan Kochanowski University, Uniwersytecka Street 7, Kielce 25-406 (Poland)

Abstract:

We present a phase-retrieval-based (interferometric, LI) approach to quantifying the bacterial growth medium diffusion through a bacterial biofilm pretreated with a tested antibacterial agent. The effect of antibacterial agents (gentamicin, colistin, and alginate lyase) on *Pseudomonas aeruginosa* PAO1 mature biofilm was additionally tested by digital holographic microscopy (DHM) and biological tests (spectrofluorimetric measurement of bacterial pyocyanin and pyoverdine production, SM). It is shown that the multimodal measurement approach (LI, DHM, SM) provides the determination of not only the bacterial cell eradication but also the bacterial matrix degradation forming a biofilm. This work was supported by the Ministry of Education and Science within the program Polish Metrology, project PM/SP/0079/ 2021/1.

The cytotoxic effect of ruthenium and copper dendrimers on eukaryotic cells measured by holographic method

Aneta Węgierek-Ciuk[1], Katarzyna Gałczyńska[1,2], Maria Baczewska[3], Arkadiusz Kuś[3], Paula Ortega[4], Francisco Javier de La Mata[4], Małgorzata Kujawińska[2], Michał Arabski[1,2]
[1] Division of Medical Biology, Jan Kochanowski University, Uniwersytecka Street 7, Kielce 25-406, Poland
[2] Central Office of Measures, Warsaw, Poland
[3] Institute of Micromechanics and Photonics, Warsaw University of Technology, Sw. A. Boboli St. 8, Warsaw 02-525, Poland
[4] University of Alcalá , Department of Organic and Inorganic Chemistry, Research Institute in Chemistry "Andrés M. del Río" (IQAR), CIBER-BBN, IRYCIS, Spain

Abstract:

This study examined the cytotoxic effect of ruthenium and copper dendrimers on CHO-K1 cells using biochemical tests and holographic methods. In detail, the cytotoxic properties were determined by biological (MTS assay and flow cytometry) and biophysical parameters. For biophysical parameters measurement we used digital holographic microscopy. This effective, label-free tool provides the possibility to perform long-term quantitative phase imaging and allows measurements of the integrated phase distribution in living cells, which can be converted to a dry mass density distribution without the use of cell markers affecting cell survival. Determination of the dry mass density distribution allows the assessment of the current stage of the cell cycle and the influence of the investigated drug. In this way, the digital holographic microscopy and the biochemical tests were compared in the determination of ruthenium and copper dendrimers cytotoxicity in eukaryotic cells, taking into account the biophysical (integrated phase distribution in cells) and biological (metabolic activity, proapoptosis/necrosis effect) parameters, respectively. This work was supported by the Ministry of Education and Science within the program Polish Metrology, project PM/SP/0079/ 2021/1.

Novel materials containing Lipoic acid and metal oxide nano particles for Hydrogel Contact Lens

Chae-Young Kim1, Seon-Young Park1 and A-Young Sung.*1
1 Department of optometry and vision science, Daegu Catholic University, Kyoung Buk, South Korea

Abstract:

Contact lenses have a wider field of view than glasses and have the advantage of no cosmetic shortcomings, so the number of wearers is gradually increasing even in its short history, and in addition to these functional purposes, they are also used for beauty purposes. If contact lenses are worn for a long time, the wearer easily feels dry due to dehydration of the lenses and the comfortable feeling decreases. In particular, silicon hydrogel materials that combine highly oxygen-permeable silicon materials and hydrophilic hydrogel materials, which have high oxygen permeability while reducing wettability due to the hydrophobicity of silicon, have been widely used recently. Dryness is an important problem related to the oxygen permeability and wettability of contact lenses, and research is actively underway to solve this problem. In recent years, the level of awareness of infectious diseases has been increasing due to the spread of COVID-19, and contact lenses directly contact the cornea, causing infectious diseases. Typically, bacteria related to eye disease include Staphylococcus aureus, E. coli, and Pseudomonas aeruginosa. Alpha-lipoic acid (ALA) is known to have antibacterial properties against Staphylococcus aureus and E. coli. Ultraviolet rays are one of the causes of various eye diseases in humans, and in particular, wavelengths in the UV-A (315-340 nm) region are absorbed by the cornea and lens, causing extreme self-hardening and cataracts. Therefore, in this study, optical and physical properties were evaluated after using R)-(+)-α-Lipoic acid (R-ALA) and metal oxide nanoparticlesas additives to manufacture hydrogel contact lenses with high humidity, UV blocking, and antibacterial properties. The α-lipoic acid increased the refractive index and decreased the water content in hydrogel materials, while silicon hydrogel materials increased the water content and decreased the refractive index. In addition, wettability and oxygen permeability increased as the ratio of α-lipoic acid added increased. If α-lipoic acid and metal oxide nanoparticles are combined with silicon materials, refractive index, wettability, oxygen permeability, and surface roughness can be adjusted according to different ratios, and it is judged that they can be used as functional lens materials.

Keywords: Ophthalmic hydrogel lens, Titanium oxide nanoparticle, Lipoic acid, Water content, Silicone hydrogel, Dryness

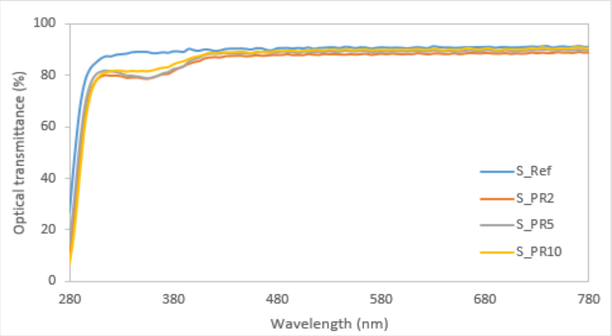

Figure 1: The optical transmittance of the samples

The prepared lens containing α-lipoic acid and titanium oxide nanopartiles were measured by wavelength band. The UV blocking ability of nano particles was lost in a lens manufactured by adding α-lipoic acid and nano particles to silicon hydrogel materials, and the loss rate increased as the ratio of α-lipoic acid increased.

Acknowledgement

This work was supported by the Techniligy development Program (RS-2023-00267665) funded by Ministry of SMEs and Startups(MSS, Korea)

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Preparation, chemical – physical characterization of composite hydrogels – nanoparticles of Ag and Ag_2MoO_4. Stability analysis and biomedical applications

S. Calistri [1,2,*], A. Ubaldini [2], A. Rizzo [2], C. M. Cellamare [2]
[1] Department of Pharmacy and Biotechnology, Alma Mater Studiorum, University of Bologna, 40126 Bologna, Italy
[2] ENEA, Via Martiri di Monte Sole 4, 40129 Bologna (Bo), Italy

Abstract:

Inorganic molybdates are promising materials for technological application in many fields. They are semiconductors with excellent physical properties such as good electrical conductibility, photoluminescence, excellent catalyst activity for many organic reactions and others. Interestingly, Ag_2MoO_4 has been claimed to have very good antimicrobial activity together with a very low toxicity. All these characteristics are often enhanced when these materials are in the form of nano/microparticles. Although there are many different ways to prepare them, in the case of silver molybdate, precipitation in aqueous solution is one of the most effective and easiest. One of the aims of the present work is to discuss the chemical-physical aspects and the influence of parameters such as temperature, pH, and concentration on the formation of microcrystals of this material via precipitation.

In any case, the particles formed are very crystalline and of good quality, but the crystalline habit can be very different depending on the case. Figure 1 shows a group of crystals obtained at 25 °C and pH =7 (a) and at 50 °C and pH = 5.5 (b)

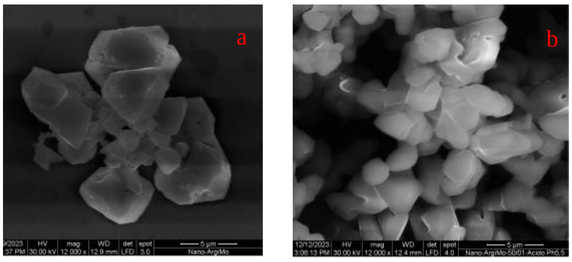

Figure 1: SEM images of Ag2MoO4 crystals prepared under different tempetature and pH.

These crystals have been characterizated by Raman spectroscopy, XRD diffraction, SEM-EDX and thermal analysis (DSC).

In order to be able to effectively use the particles thus produced, especially in the biomedical field, but not only, hydrogel-nanoparticle composites have been created, so as to be able to combine effective properties with ease of use.

Different gels were prepared, with different water contents and the polymer matrix was of both biological origin (chitosan/cellulose) and chemical synthesis (polyalcohol). The most effective method for dispersing the particles in the hydrogel and the compatibility between them and the matrix were studied. The sedimentation and aggregation of crystals are phenomena to be avoided. Small amounts of surfactants have proven useful. To also understand the effect of particle size on the formation of uniform dispersions, the case of silver nanoparticles, prepared by chemical reduction, was also studied because they are much smaller.

Finally, the effectiveness of both the hydrogel-particle compounds and the microcrystals as such as inhibitors of bacterial growth (Escherichia coli) was tested. Both cases proved to be very efficient.

pH-sensitive polymer nanoparticles preparation - a nanoplatform for 5-fluorouracil delivery

Ivelina Ivanova[1], Teodora Popova[1], Marta Slavkova[1], Borislav Tzankov[1], Christina Voycheva[1]
[1] Department of Pharmaceutical Technology, Medical University - Sofia, Bulgaria

Abstract:

The new polymer was synthesized by grafting acrylic acid (AcA) onto agar agar (AA) backbone. Fourier transform infrared spectroscopy (FTIR), nuclear magnetic resonance (NMR), and differential scanning calorimetry (DSC) were performed to prove the successful grafting and the formation of a new polymer. pH-sensitive nanoparticles, prepared by using glutaraldehyde (GA) as a crosslinker, were loaded with 5-fluorouracil (5-FU). The resulting nanoparticles were characterized by transmission electron microscopy (TEM), and dynamic light scattering (DLS). Drug loading efficiency (DLE), and drug release were also determined.

Agar was dissolved in distilled water at 90°C in a three-neck round bottom flask with a gas inlet system and a condenser followed by the addition of acrylic under stirring. Nitrogen gas was poured for 60 minutes before the addition of a solution of cerium ammonium nitrate (CAN) in water, acidified with concentrated HNO_3. The reaction continued in a thermostatic paraffin bath under stirring for 6 h at a constant temperature of 70°C. The grafting procedure terminated by adding a saturated hydroquinone solution when a separating funnel splits the resulting polymer AA-g-AcA from the homopolymer. Finally, the graft copolymer hydrogel was precipitated over acetone, separated by centrifugation, dried to a constant weight, and grounded.

The empty (npAA-g-AcA) and loaded with 5-FU nanoparticles (npAA-g-AcA/5-FU) were prepared in different drug/polymer ratios and crosslinker amounts. GA is used as a crosslinker. Increasing the amount of polymer in the drug/polymer ratio results in the retention of a greater amount of 5-FU in the particles. The drug loading efficiency decreases with an increase in the amount of drug used during the preparation of the nanoparticles. Maximum DLE was found at a drug/polymer ratio of 1/3. Increasing the amount of GA leads to an increase in the DLE value, most likely due to the tighter crosslinking, which allows a greater amount of 5-FU to be retained.

TEM studies were performed for analysis of the size, shape, and structure of npAA-g-AcA and npAA-g-AcA/5-FU nanoparticles.

The results of the empty nanoparticles demonstrate spherical shape, nanoscale size, matrix structure, and narrow distribution.

Measurements performed by DLS analysis show that the size of the obtained particles are in the nano range. The nanoparticle’s diameter for both polymers increased after loading of the drug.

The PDI value of the empty nanoparticles demonstrates the narrow limit in size distribution, proving their stability. Decreasing of PDI was observed after 5-FU loading.

In vitro dissolution test shows the pH-dependent release of 5-FU in pH 7.4 and 5.0 buffer media at 37°C. The results are presented in the figure.

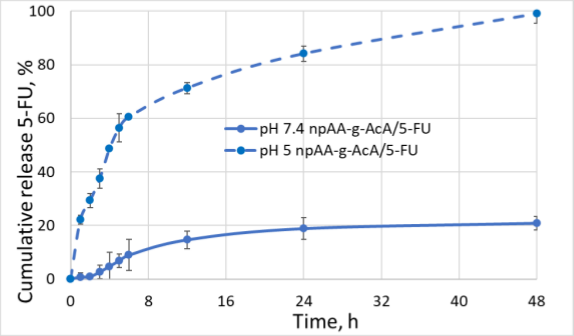

Figure 1: Release profiles of 5-Fluorouracil from npAA-g-AcA in a buffer medium with a pH of 7.4 and pH of 5 at temperature 37°C, 100 rpm; n = 3 ± SD

Keywords: grafted polymer, pH sensitivity, 5-FU, nanoparticles

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Funding

European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0004-C01.

Investigation of the effects of the preparation method on the properties of nanostructured lipid carriers

Marta Slavkova [1], Christina Voycheva[1], Teodora Popova[1], Borislav Tzankov[1]
[1] Department of Pharmaceutical Technology and Biopharmacy, Medical University –Sofia, Bulgaria

Abstract:

Nanostructured lipid carriers (NLCs) are a group of lipid based nanoparticles with a lot of advantages including biocompatibility, biodegradability, improved bioavailability of lipophilic drugs and increased loading capacity. Different lipids and methods of preparation can be applied. Therefore, the present study investigated the effect of two distinct methods for NLC preparation on the properties of the final product. Berberine hydrochloride was used as a model drug. It is a well-known isoquinoline alkaloid with a plethora of pharmacological activities such as antioxidant, anticancer, antidiabetic, anti-inflammatory and other effects. Nevertheless, all those benefits are hindered due to berberine's low bioavailability. It is due to the limited aqueous solubility of the drug, together with it being a substrate of the P-glycoprotein efflux system.

A preformulation study investigating the suitability and compatibility of different solid and liquid lipids was conducted. The optimal lipids were then used for the preparation of nanostructured lipid carriers (NLC) based on the hot-emulsification method followed by pulse ultrasonication. Alternatively, the same qualitative composition of lipids was used in the solvent-evaporation technique. The nanoparticles obtained by different methods were further loaded with berberine hydrochloride and consequently characterized.

All nanoparticles samples were characterized for their particle size, polydispersity index and zeta potential by dynamic light scattering analysis. Encapsulation efficiency and drug loading capacity was investigated indirectly. Transform Infrared spectra were collected with a Thermo-Nicolet FTIR instrument and analysed for possible interactions between the components. The surface morphology was evaluated by scanning electron microscope. In vitro dissolution studies were conducted in a thermostated incubator shaker over 7 days.

The current study is a preliminary research that presents the effect of compositional and technological parameters on the prepared nanostructured lipid carriers. As a model drug berberine was utilized and its release profiles were characterized. The results suggest the suitability of the NLCs for berberine delivery and possible therapeutic application.

Keywords: berberine, preformulation, lipid nanoparticles, hot-emulsification method, solvent evaporation method

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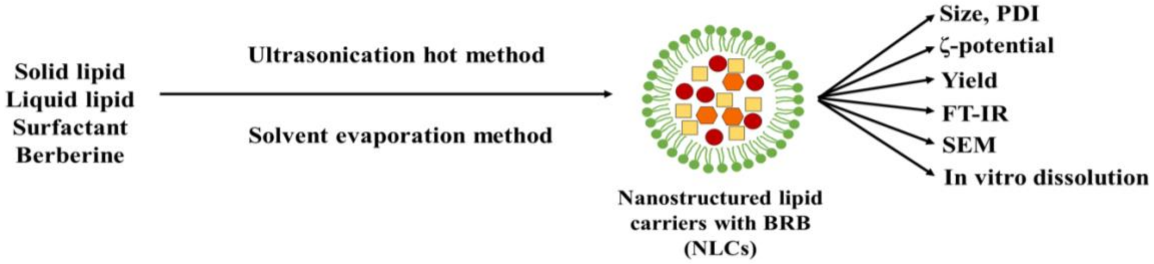

Figure: Schematic illustration of the structure of NLCs with Berberine and the investigated parameters

Non-carboxylated and Carboxylated Mesoporous Carbon Nanoparticles Loaded with Bicalutamide – an Advanced Nanosystem for Combined Chemo-photothermal Therapy

T. Popova[1], B. Tzankov[1] , M. Slavkova[1], Y. Yordanov[1], V. Georgieva[1], D. Stefavova[1], V. Tzankova[1], D. Tzankova[1], Iv. Spasova[2], D. Kovacheva[2], Ch. Voycheva[1]
[1]Faculty of Pharmacy, Medical University of Sofia, Sofia, Bulgaria
[2]Institute of General and Inorganic Chemistry, Bulgarian Academy of Sciences, Sofia, Bulgaria

Abstract:

Bicalutamide (BLT) is an antineoplastic agent used to treat prostate cancer. Its low water solubility is an important reason for the unsatisfactory therapeutic outcomes. Improvement of the therapeutic effect of BLT into this study is achieved by its incorporation into non-carboxylated (MCN/BLT) and carboxylated (MCN-COOH/BLT) mesoporous carbon nanoparticles. This carriers are chosen because of their high storage hydrophobic internal capacity, especially for aromatic drugs (like BLT), easily-grafted surface, as well as photothermal capacity under near-infrared light (NIR). Fourier-transform infrared spectroscopy (FTIR) was performed to reject any possible interactions between the active pharmaceutical ingredient (API) and the carriers. Dynamic light scattering (DLS) was used to determine the Z-potential, particle size and polydispersity index. Carboxylated MCNs exert increased dispersibilty (due to hydrophilic –COOH groups expressed over the external surface of the nanoparticles) and significant encapsulation efficiency for BLT. Besides this, they show slower release rate of the API as well as higher cytotoxicity against prostate cancer cells, compared to non-carboxylated BLT-loaded samples. In-vitro release studies, as well as cell-viability test were performed with or without NIR-irradiation. The experiments demonstrate that NIR-light provokes faster dissolution speed as well as increased cytotoxicity. This is the reason to consider that the obtained nanosystems could be considered as potential drug delivery systems for combined chemo-photothermal therapy of prostate cancer since they express extended release of the API, enabling the intracellular transport, combined with increased NIR-triggered cytotoxicity.

Keywords: Mesoporous carbon nanoparticles, photothermal effect, bicalutamide, extended release.

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Funding

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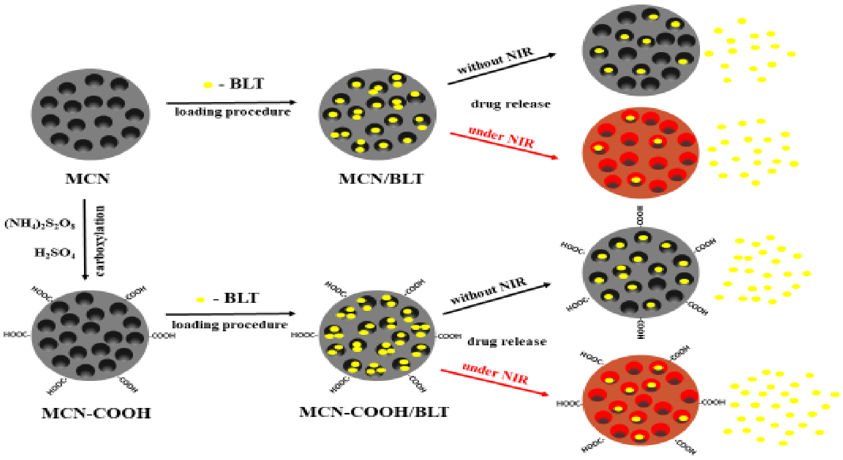

Figure: Schematic illustration of BLT loading procedure into non-carboxylated and carboxylated MCN nanosystem as well as NIR-triggered drug release.

Development of Innovative Drug Delivery System for Optimized Therapy of Traumatic Skin Conditions

B. Tzankov[1], T. Popova[1], Iv. Spasova[2], D. Kovacheva[2], Ch. Voycheva[1], M. Slavkova[1]
[1]Faculty of Pharmacy, Medical University of Sofia, Sofia, Bulgaria
[2]Institute of General and Inorganic Chemistry, Bulgarian Academy of Sciences, Sofia, Bulgaria

Abstract:

Traumatic skin diseases affect the integrity of the skin, in which its protective function is significantly compromised, which allows the occurrence of microbial invasion, in which the risk of localized colonization and systemic entry of microbes of endogenous and exogenous origin increases. Some groups, such as patients with diabetic neuropathy, patients with mental disorders, children, etc. are more vulnerable to these disabilities.

To prevent the occurrence of infection and sepsis in such conditions, new therapeutic approaches are needed, and the application of nanotechnology is an area of high potential.

When skin integrity is compromised, a restorative response occurs involving four stages of repair: hemostasis, inflammation, proliferation, and remodeling. This regenerative process is potentially hindered by infection, which can be of fungal or bacterial origin, the most common microorganisms being Staphylococcus aureus (gram-positive bacteria), Pseudomonas aeruginosa (gram-negative bacteria) and Candida spp. (mushrooms). Antibiotic therapy, both topical and systemic, plays an important role in the treatment of wound infections. However, systemic antibiotics are highly associated with resistance mechanisms that compromise the treatment process. For local wound treatment, the deeper the burn extends and the thickness of the scab increases, the less reliable the administration of systemic antibiotics is. Therefore, topical antibiotics have emerged as an alternative treatment, and when incorporated in an appropriate dosage form can provide a high and sustained concentration of the antimicrobial agent at the site of infection. Despite their potential benefits, the results obtained with topical antibiotic therapy are still suboptimal, reinforcing the need for innovation in topical antibiotic delivery systems.

Interesting approach for improved therapy would be the simultaneous incorporation of silver nanoparticles and antibiotics into the mesoporous particles (Figure 1), by which to increase the efficiency of the systems and is a possible approach to overcome antibiotic resistance. In turn, the inclusion of suitable penetration enhancers in the composition would lead to an increase in skin permeability for the developed mesoporous nanosystems. The development of a suitable dosage form for the obtained nanosystems is an additional challenge directly related to increasing the quality of therapy.

Keywords: mesoporous silica nanoparticles, penetration enhancers, skin nanotherapy;

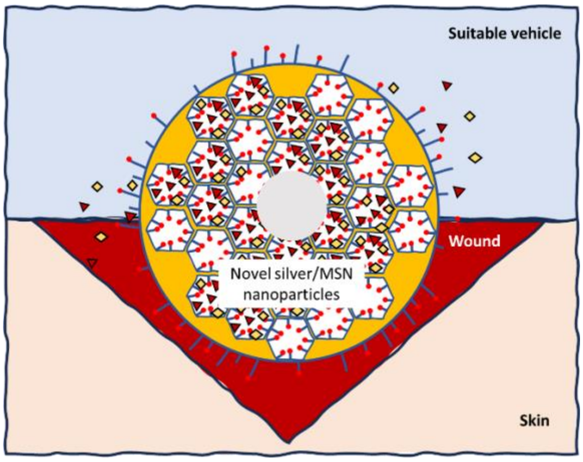

Figure 1: Schematic representation of novel silver/MSN nanoparticles loaded with antibiotics and penetration enhancers incorporated in suitable dosage form

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Design of new nano-tools to target mitochondria and study the metabolic plasticity of cancer cells

Dorna Akbarzadeh[1*], Juan Carlos Calderón de la Rosa[1,2] Jolanda Spadavecchia[3], Marie-Odile David[4],
François Treussart[5], Nazanine Modjtahedi[1], Giorgia Urbinati[1]
[1] University Paris-Saclay, CNRS, Gustave Roussy, Metabolic and systemic aspects of oncogenesis for new therapeutic approaches, Villejuif, France
[2] University Paris Cite, Faculty of Pharmacy, Paris, France
[3]UniversityParis13, Sorbonne Paris Nord ,CNRS, Laboratoire de Chimie, Structures et Propriétés de Biomatériaux et d'Agents Thérapeutiques, Bobigny, France
[4]University Paris-Saclay, Inserm, Univ Evry, Structure-Activité des Biomolécules Normales et Pathologiques, 91025 Evry,France
[5]University Paris-Saclay, École Normale Supérieure Paris-Saclay, CNRS, CentraleSupélec, LuMIn, 91190 Gif-sur-Yvette, France

Abstract:

The metabolic plasticity and mitochondrial functionality are crucial factors in tumorigenesis and response to anti-cancer therapy making the mitochondrion an attractive target for innovative anticancer therapies (1-2). Several bioactive molecules have been developed to modulate/perturbe mitochondrial activity with the final aim of introducing alternative cancer treatment strategies. However, the efficacy of these biomolecules depends on their accumulation within mitochondria at the right dose, while preserving their activity (3). With this intent, nanovectors can be tailor-made to target mitochondria, to deliver these molecules sub-cellularly and therefore improve their bioavailability while reducing their off-target toxicity (4). Our team has developed a major interest for the mitochondrial import machinery AIF/CHCHD4, which regulates the mitochondrial import of proteins involved in cell survival and regulation of apoptosis, representing a potential therapeutic target in oncology (5). A peptide able to inhibit the *in vitro* interaction of AIF/CHCHD4 was identified by our team and represents a novel biomolecule with potential anticancer activity (6). Since this peptide is fragile, highly hydrophilic and negatively charged, two innovative nanovectors are developed in our laboratory with the aim of preserving the peptide's *in cellulo* functionality, while favoring its sub-cellular localization in the mitochondrion. The first strategy uses a classical liposomal-based system (Figure 1a). The second one is based on an innovative approach, using Fluorescent nano-diamonds (FND) for the tracking of the nanosystem down to the mitochondrion (Figure 1b). Five liposome formulations were prepared and characterized for their size, stability, release kinetics and cellular uptake. A chemical molecule with mitochondria tropism was grafted on the surface of these nanocarriers. The most promising liposomal formulation presented a size of ~200 nm with a homogenous distribution and a loading capacity of the peptide of ~20%. The peptide release kinetics was sustained over 72h in buffer conditions. In parallel, the FND nanovector was loaded with the therapeutic peptide and functionalized with the mitochondria targeting peptide. The loading efficacy of the therapeutic peptide is 30% obtained after purification and the addition of the targeting peptide stabilized the complex, which tends to aggregate when in presence of the therapeutic peptide alone. We are now validating the mitochondrial localization of the nanovectors with imaging and biochemistry analysis. The study of the impact of AIF/CHCHD4 inhibition on the metabolic plasticity and survival of cancer cells is also under study.

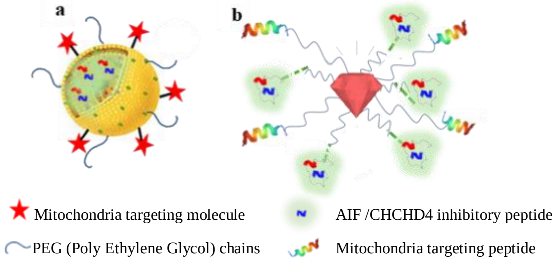

Figure 1. Schematic representations of two nanovectorization approaches for targeted delivery of the inhibitory peptide to mitochondria. (a) Liposome-based formulation encapsulating fluorescently labeled peptide and a mitochondria-targeting moiety. (b) Functionalized fluorescent nanodiamonds (FNDs) used to encapsulate the bioactive peptide and target mitochondria. Each approach offers distinct advantages and challenges in achieving efficient delivery to the mitochondrion.

Keywords: Nanovectorization, liposomes, fluorescent nanodiamonds, mitochondria-

targeting, mitochondrial metabolism, metabolic plasticity.

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Role of Nanoparticle-Based Drug Delivery Systems Pharmaceutical Properties into Shaping the Risk-Benefit Ratio of Investigational Medicinal Products in Clinical Studies for Cancer Treatment

H. Abdel-Haq
National Center for Drug Research and Evaluation, Istituto Superiore di Sanità, Rome, Italy

Abstract:

In recent years, nanoparticle-based drug delivery systems have been increasingly implemented in clinical experimentations. This greater consideration for these innovative systems is mainly due to the need to improve the distribution profile of drugs in certain tissues, in particular brain and tumor tissues, and to reduce their toxicity. Indeed, compared to conventional drugs, nanoparticle-based drug delivery systems are prepared from biodegradable materials, such as liposomes, polymers or polymeric micelles, which owe particular chemical-physical properties that allow them to cross certain barriers and membranes, such as the blood brain barrier, and to selectively reach desired target sites. Several studies suggest that the pharmaceutical properties of nanoparticle-based drug delivery systems play a crucial role in the failure of several clinical trials due to critical limitations inherent to the pharmaceutical properties of the nanoparticles themselves. As well as, these studies revealed that nanoparticles properties participate in defining the final risk-benefit ratio of the investigational medicinal product in clinical trials. This study aims to elucidate why and how the pharmaceutical properties of nanoparticle-based drug-delivery systems can positively or negatively affect the clinical trial outcome and how they can push the risk-benefit ratio towards the risk or benefit. This study focuses the analysis on clinical trials for cancer treatment being the field in which these innovative systems are extensively involved since their initial pharmaceutical development. Nanoparticles size, shape, charge, stability, pH, loading and releasing capacity, characteristics of the polymers chosen for preparing nanoparticles and polydispersity of the nanoparticles were found to be the pharmaceutical properties that may have a major and significant impact on the therapeutic outcome and consequently on the clinical trial success or failure. The reason for this opposite influence is attributed to the lack of standard protocols and dedicated regulations for the manufacturing and development process of nanoparticles. Based on these findings, it is essential and may be considered as a mandatory step to perform an optimization of the nanoparticles pharmaceutical properties during the early stages of their pharmaceutical development followed by a harmonized regulation by competent regulatory agencies not only concerning the good manufacturing practice (GMP)-based quality assessment but also concerning the homogeneity of the formulations and basic parameters relative to the manufacturing process prior to the implementation of nanoparticles in clinical trials. The adoption of these suggested measures could, on one side, circumvent potential limitations and, on the other side, emphasize the overall benefits of nanoparticle-based drug-delivery systems thus making them more effective and safer for the clinical practice.

Keywords: Nanoparticles, nanoparticles-based drug-delivery, clinical trials, Risk-benefit ratio, Pharmaceutical properties, Cancer therapy.

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DNA nanotechnology to fight infectious diseases

M. Cambra-Pellejà [1,2,*], Q. Yang[1], L. Baptista-Pires [2,3], Miguel Vilaplana[2], Jose Muñoz[1,4], Javier Gandasegui[1]
and Claudio Parolo[1]
[1] Barcelona Institute for Global Health (ISGlobal) Hospital Clínic - Universitat de Barcelona, Barcelona, Spain.
[2] GraphenicaLab S.L., Barcelona, Spain.
[3] Department of Physics, University of Aveiro, Aveiro, Portugal.
[4] CIBERINFEC, ISCIII - CIBER de Enfermedades Infecciosas, Instituto de Salud Carlos III, Centro de Investigación Biomédica en Red de Enfermedades Infecciosas, Madrid, Spain.

Abstract:

Antibodies play a crucial role in the immune system's defense against infectious pathogens by specifically recognizing and neutralizing antigens[1]. The detection of antibodies in individuals suspected of infection is pivotal for diagnosing infectious diseases and evaluating the effectiveness of vaccination programs[1]. However, certain diseases, notably HIV and helminthiasis infections, present technical challenges in accurate diagnosis particularly in point-of-care settings[1,2,3]. In response to these challenges, DNA scaffold sensors have emerged as promising tools for the diagnosis of infectious diseases[4]. These sensors are constructed using a rigid nucleic acid scaffold, attached to an electrode, and presenting both a redox reporter and an epitope[3]. In the absence of antibodies, the redox reporter efficiently transfers electrons during electrochemical interrogation. However, upon antibody binding, steric hindrance restricts the movement, leading to a reduction in electron transfer, which can be quantitatively measured and correlated with the target concentration. The utilization of DNA scaffold sensors offers advantages over conventional diagnostic methods, including enhanced sensitivity and specificity[2]. In conclusion, DNA scaffold biosensors offer a rapid, single-step methodology for the quantitative detection of antibodies in small volume samples. Their potential for use in point-of-care applications holds promise for improving the diagnosis and management of infectious diseases, particularly those presenting technical difficulties such as HIV and helminthiasis infections.

Keywords: DNA scaffold sensors, antibodies, infectious diseases, HIV, helminthiasis, diagnosis, point-of-care applications.

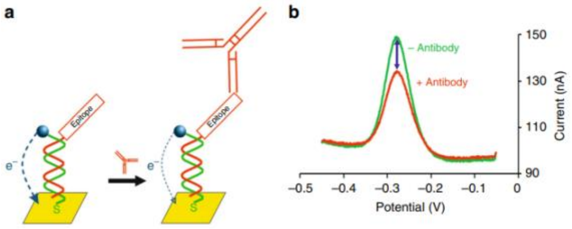

Figure 1: Figure illustrating the functionality of the DNA scaffold sensor for the rapid measurement of specific antibodies. (a) In the absence of the targeted antibody, the DNA scaffold facilitates efficient electron transfer to the gold electrode. However, upon antibody binding, steric hindrance reduces electron transfer. (b) This alteration in electron transfer rate is readily discernible through square wave voltammetry.

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Microfluidics based homogenous size chlamydial nanovaccine potentiates immune responses

Vida A. Dennis [1*], Rajnish Sahu [1], Logan Gildea [1]
[1] Center for NanoBiotechnology Research, Alabama State university, Montgomery, Alabama, USA

Abstract:

Chlamydia trachomatis is the most reported bacterial sexually transmitted infection (STI) globally, with a reported 100 million infections per year. Responsible for several diseases, including conjunctivitis and blinding trachoma, non-gonococcal urethritis, cervicitis, pelvic inflammatory disease, ectopic pregnancy, tubal factor infertility, and interstitial pneumonia, this pathogen presents a severe burden to public health. Considering this, a prophylactic vaccine against *C. trachomatis* is highly desired to combat this pathogen.

We have developed an efficacious nanovaccine (nV) comprising poly(lactic-co-glycolic acid) PLGA encapsulating chlamydial major outer membrane protein MOMP and named as PLGA-rMOMP. However, conventional methods to fabricate nanoparticles often lack size uniformity and bench to bench reproducibility, especially sub 100 nm size. Microfluidics based fabrication of nanoparticles is becoming a forefront of nanotechnology due to the tunable size and reproducibility by rapid mixing of the aqueous and organic solutions in microchannels. However, the desired nanoparticle size remains challenging and thus optimization was performed. We hypothesized that the microfluidics based homogeneous size nanoparticles will induce robust immune responses compared to the conventionally fabricated nanovaccine. Organic phage (PLGA; 5 mg/mL in acetonitrile) was emulsified with aqueous phase (2% polyvinyl alcohol containing 150 μg/mL of rMOMP) in a microfluidics device using high-throughput mixing chamber at a flow ratio (1:1) and total flow rate (30 mL/minute). The control nanoparticles were prepared by adding PBS into the aqueous phase. The zeta-size assessment showed an average of 85 nm size nanoparticles (Figure 1) with the lower polydispersity index (0.067) were produced. The nanoparticles were collected by high-speed centrifugation, washed with PBS and lyophilized. Murine macrophages (J774A.1) were stimulated with homogeneous (nV-85nm) and conventional (nV) nanovaccine at concentrations of encapsulated rMOMP (2.5, 5 and 10 μg/mL). The results show that the nV-85nm induced clathrin (>2 fold) gene expression at all concentrations tested, but induced higher TLR-2 (8-fold) activation at the lowest (2.5 μg/mL) concentration, compared to nV. This suggests the efficient uptake of nV-85nm and potentiating antigen-specific responses by using a smaller quantity. We also observed significantly ($p < 0.01$) high production of IL-6 (>50-fold), IL-12 (>8-fold), and especially TNF-α (>20-fold) in nV-85nm (2.5 μg/mL) stimulated cells compared to nV, which were further increased at higher concentrations (5 and 10 (2.5 μg/mL). In conclusion, the homogeneous size nanoparticles induced robust antigen-specific immune responses by effective delivery of antigen and also showed the potential to develop a novel nanovaccine candidate for chlamydia.

Keywords: Microfluidics, PLGA nanoparticles.

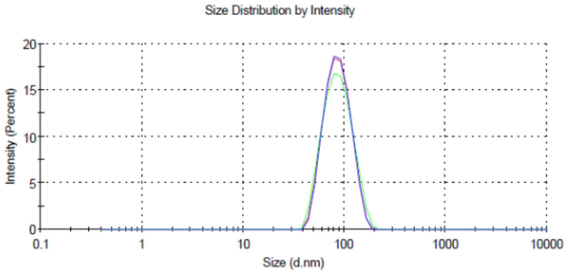

Figure 1: Figure illustrating the zeta-size analysis of microfluidics based PLGA nanoparticles fabrication.

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Risk Assessment of Nanomaterials and Development of GIS-Based Decision Support System for Environmental and Human Health Protection

S. J. Son*, J. H. Kim, J. W. Kim, S. H. Yoo, Y. H. Cho
Sundosoft Co., Ltd., Seoul, Republic of Korea

Abstract:

Nanomaterials, defined as particulate substances with dimensions of 1-100nm, are widely utilized in chemical and bio-industrial sectors, particularly as manufactured nanomaterials. The precise characterization of these materials and their interactions with the human body remains elusive, with limited research focused on the potential risks nanomaterials pose to human health and the environment. Nanotoxicology, a discipline dedicated to evaluating the potential threats of nanomaterials, has become increasingly significant in assessing how these materials may endanger the environment and human well-being. This study aims to accurately assess the risks posed by nanomaterials and employ a GIS-based intelligent decision support system for disaster situations to track nanomaterials within the environment and detect contaminated areas, thereby safeguarding human health and the environment.

This research has developed a decision support system for managing pathogen contamination in disaster situations using GIS technology. The system integrates various technical means, including satellite and drone-based water quality data collection and analysis, and the evaluation of water pollution severity using social media data. This allows for the rapid and accurate detection and response to the environmental risks posed by nanomaterials. The system is interconnected with various information sources via REST and open APIs and effectively manages data using MongoDB and GeoServer.

The study is expected to contribute significantly to protecting the environment and human safety by providing more accurate risk assessments of nanomaterials and offering the necessary technical means to respond to pathogen contamination in disaster situations. Specifically, the system will enhance the capacity to respond to unidentified risks and strengthen disaster response capabilities, thereby reducing industrial accidents. This research will also provide essential data for policy-making and regulatory development aimed at the safe use of nanomaterials and environmental protection.

Keywords: Nanomaterials, Nanotoxicology, GIS-based Decision Support, Environmental Health, Risk Assessment, Water Pollution.

Figure 1: Figure illustrating the lists all components of PathoCERT that integrate with PathoWARE in various ways. The technologies that integrate with PathoWARE are. PathoTWEET which provides data to PathoWARE, particularly the analysis done on tweets. PathoSAT that provides data to PathoWARE, particularly satellite data obtained through analysis of satellite images of Water Body. PathoCAM which provides data to PathoCAM by continuous monitoring of turbdity value of some pilot lakes. PathoSENSE IoT Gateway that provides data to PathoWARE regarding information collected from water sensors. Real Time Analytics which provides data to PathoWARE regarding detection of alarms. PathoDRONE which provides data to PathoWARE about images captured by the drone. PathoINVEST that consumes and provides data to PathoWARE about the missions, requests, and reports it generates. PathoGIS which consumes data from PathoWARE in order to display it on a map. PathoVIEW which produces and consumes data from PathoWARE to display and create alarms from users.

Acknoledgment

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Enhanced Stability and Reusability for Purifying Therapeutic Antibodies a Ca^{2+} -responsive Fusion Protein Development

Heesun Park [1,2,], Sunghyun Kim [1*]
[1] Bioceramic Materials, Korea Institute of Ceramic Engineering and Technology (KICET), Cheongju, Republic of Korea
[2] Life science and biotechnology Division of life science, Korea University, Seoul, Republic of Korea

Abstract:

Protein-A affinity chromatography is a stnadard performance in therapeutic antibody purification industry. The process includes protein A beads that separate purifying antibody and impurities in culture media by lowering pH. They can be reused after purification by CIP(Clean-In-Place) process, in which alkaline such as NaOH is used. Therefore, we developed an antibody purification platform with enhanced stability in alkaline and protease for efficient reuse of the ZZ-CSQ (Figure 1). The cleavage site of an engineered fusion protein in alkaline and protease was checked by N-terminal sequencing, and then changed stronger to produce an improved fusion protein for antibody purification in alkaline and protease. As a result, the purification yield and quality of an improved fusion protein was efficient as much as conventional protein-A affinity chromatography. Further, degradation of the improved fusion protein under alkaline and protease conditions was negligible. This emphasizes the reusability of an improved fusion protein for antibody purification using alkalin. The result of this study implies that the enginnered ZZ-CSQ precipitation method can reduce the cost of producing therapeutic antibodies and is a more effective and economical means of purifying antibodies than earlier techniques.

Keywords: antibody purification, calcium-depnedent, biopolymer, reverse transition, therapurics antibody, protein engineering.

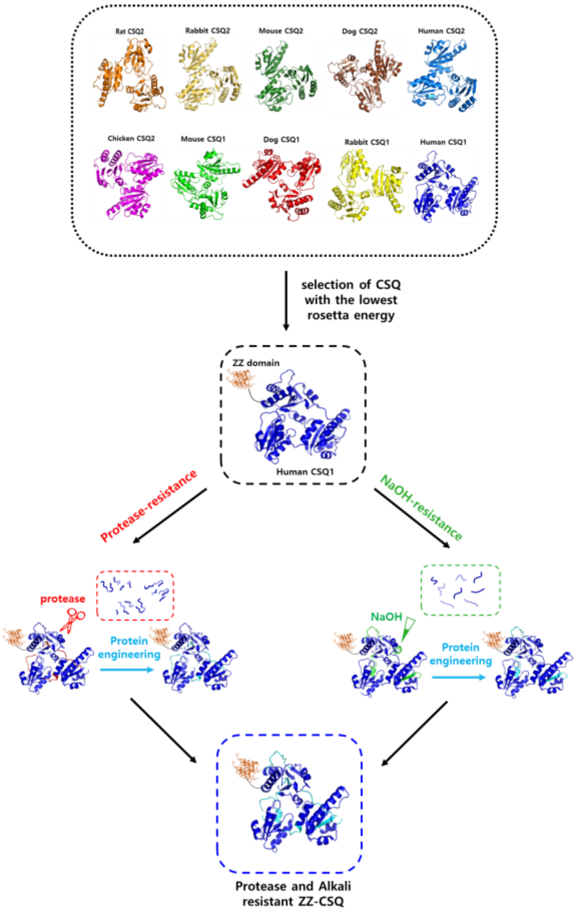

Figure 1: Illustrate the representation of the development process of reusable and stable ZZ-CSQ.

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Effect of Barcopa monnieri extract on autophagy and apoptosis in lung cancer A549 cell

W. Poorahong [1], S. Innajak [2], P. Sitthisuk [2], E. Tashiro [3], M. Imoto [4], and R. Watanapokasin [2, *]
[1] Department of Biochemistry, Faculty of Medicine, BangkokThonburi University, Bangkok 10170, Thailand
[2] Department of Biochemistry, Faculty of Medicine, Srinkharinwirot University, Bangkok 10110, Thailand
[3] Laboratory of Biochemistry, Showa Pharmaceutical University, Tokyo 194-8543, Japan
[4] Graduate School of Medicine, Juntendo University, Bunkyo-ku, Tokyo 113-8421, Japan
[*] Correspondence

Abstract:
Cancer is one of the most serious health problems globally. While the finding of new agents with anticancer properties remains a challenge due to treatment failure, which is generally caused by drug resistance. *Bacopa monnieri* L. (BM), a medicinal plant, has shown many biological activities such as antimicrobial, antioxidant, and anti-inflammatory activities. However, the effects of BM extract on anti-cancer activity and the underlying molecular mechanisms in a human lung adenocarcinoma A549 cell line is not clear. In this study, we found that BM extract inhibited lung cancer cell growth by decreasing cell viability in a dose-dependent manner with an IC_{50} value of 35.62±0.77 µg/mL. Morphological changes and mitochondrial membrane potential examination indicated that BM extract induced nuclear condensation and loss of mitochondrial membrane potential, which are apoptosis markers. Western blot analysis showed that BM extract down-regulated anti-apoptotic proteins; Bcl-xL and Bcl-2 while increased Bak, cleaved-caspase -7. Additionally, BM extract enhanced the phosphorylation of MAPK proteins and decreased Akt signalling proteins in A549 cells. Interestingly, BM extract attenuated autophagy via increased LC3-II expression when compared to an autophagy inhibitor. Taken together, these findings suggest that BM extract exerts anti-cancer activity through inhibiting autophagy, an intracellular recycling system, and enhancing apoptosis in A549 cancer cells and may have potential as a therapeutic drug for lung cancer.

Keywords: Barcopa monnieri, autophagy, apoptosis, lung cancer

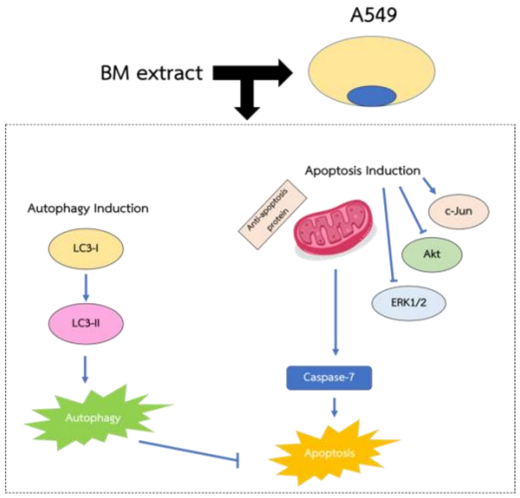

Figure 1: Illustrating of apoptosis induction associated with autophagy inhibition in A549 cells by BM extract.

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Viability and cell migration of chitosan-pluronic F127 and reduced graphene oxide hydrogels as wound healing dressings

I. Ruíz [1,*], K. Frnández[1], C. Aguayo[2]
[1] Laboratory of Biomaterials, Department of Chemical Engineering, Faculty of Engineering, University of Concepción, Box 160-C, Concepción, Chile
[2] Department of Clinical Biochemistry and Immunology, Faculty of Pharmacy, University of Concepción, Box 160-C, Concepción, Chile

Abstract:
Hydrogels are one of the most widely used biomaterials in biomedicine studies for tissue regeneration. In this sense, the synthesis of new precursors of nanomaterials and/or smart materials has allowed new formulations to be made based on compounds such as graphene oxide (GO) and its derivatives. This material can be functionalized due to its functional, antibacterial, mechanical, conductive, and thermal properties. Chitosan (CS) is a material of natural origin widely used in biomedicine due to its biocompatible, biodegradable, anti-inflammatory properties, low toxicity, and easy functionalization with other negatively charged synthetic or natural polymers. In this study, biomaterials based on chitosan-pluronic F127 (CS-PF) and reduced graphene oxide (rGO) were formulated to be used as patches in wound tissue regeneration and to evaluate their viability and migration. The materials were synthesized at different mass ratios of rGO (0, 0.5, 1), keeping the mass amount of CS-PF constant (1). HDF1 was used in cytotoxicity and cell migration assays. The results obtained in the MTT test showed that the biomaterials are not toxic, since they all presented cell viability values greater than 80%. Furthermore, it was observed that increasing the CS-PF-rGO ratio favored cell viability, reaching a value of 120% in the case of CS-PF-rGO (Figure 1A). The increase in the proportion of rGO favors cell migration. CS-PF-rGO presented a larger wound closure area and a higher healing rate than CS-PF (Figure 1B). It is postulated that rGO could provide a pathway for transmitting electrical signals between the wound and cells, thereby regulating cellular behavior and promoting wound healing. The results obtained demonstrate that the synthesized materials are potential candidates for use as dressings in wound healing.

Keywords: Hydrogel, reduced oxide graphene, cell viability, cellular migration.

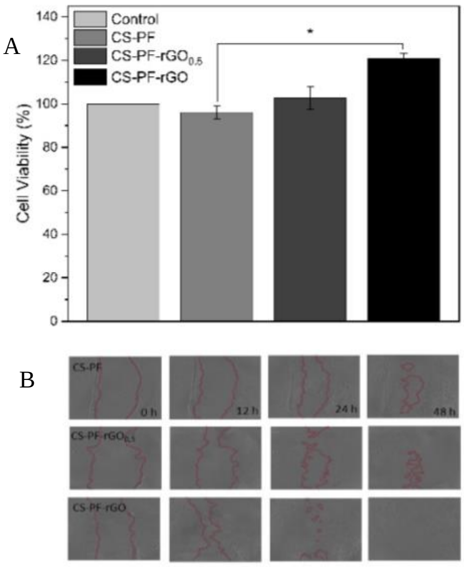

Figure 1: Figure illustrating: (A) Viability of human fibroblast cells; (B) Images of wound closure at times 0, 12, 24, and 48 h for the hydrogels. Statistical significance was determined by multivariate ANOVA and the asterisk indicates significant differences at a 95% confidence level according to the Tukey test.

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Valorization of grape pomace by obtaining some functional ingredients with antioxidant and antimicrobial activities

E.I. Geană[1], C.T. Ciucure[1], R. Tamaian[1], I.C. Marinaș[2], M.S. Stan[2], R.E. Ionete[3]
[1]National Research and Development Institute for Cryogenics and Isotopic Technologies – ICSI Ramnicu Valcea, 4th Uzinei Street, 240050 Ramnicu Valcea, Romania
[2]Research Institute of the University of Bucharest-ICUB, Bucharest, Romania

Abstract:
The agro-food industry, particularly grape pomace, presents a growing challenge in recovering valuable compounds from by-products[1]. Grape pomace, rich in polyphenols with antioxidant, anti-inflammatory, and anti-carcinogenic properties[2], presents a po-tential source for effective extraction and reuse in the food, cosmetic, and pharmaceu-tic industries, given its large-scale production in wineries.This study aim to obtain polyphenolic extracts with high antioxidant and antimicrobial activities obtained from grape pomace by the sequential use of enzymatic and microwave-assisted extractions, followed by purification of the extracts in order to remove sugars. The obtained extracts were characterized in terms of total polyphenol content (TP), total flavonoid content (TF), antioxidant activity (AA), polyphenol profile by UHPLC-MS/MS, antimicrobial activity, toxicity and biocompatibility. The enzymatic extraction was performed with pectinase (50 µL enzyme/gram pomace) in citric acid solution pH = 4.0 at a solid:liquid ratio = 1:7.5 (w/v), homogenization for 20 hours at a temperature of 35 °C, while the microwave-assisted extraction was performed in 50% hydroethanolic solution, at a solid liquid ratio of 1/15 (w/v), 1000 W microwave power, applied during 35 min., at a temperature of 60 °C, with stirring. The obtained functional ingredients demonstrated high polyphenol extraction yields, namely: 1550 mg polyphenolic extract/100 g pomace of white grapes, Chardonnay variety, respectively 3150 mg extract/100 g red grape pomace, Cabernet Sauvignon variety. The functional polyphenolic extract obtained from white grape pomace show a TP of 438.27 mg GAE/g extract, TF of 19.78 mg QE/g extract, AA of 5112.34 µM TE/g extract and a polyphenolic profile characterized by compounds such as procyanidin B2 (916.53 µg/g), catechin (377.35 µg/g), epicatechin (247.01 µg/g), quercetin (366.98 µg/g), kaempferol (435.10 µg/g), syringic acid (115.13 µg/g). The functional polyphenolic extract obtained from red grape pomace show a total polyphenol content of 618.58 mg GAE/g extract, total flavonoid content of 51.39 mg QE/g extract, antioxidant activity of 6908.30 µM TE/g extract and a polyphenolic profile characterized by compounds such as procyanidin B2 (1426.54 µg/g), oenin (833.58 µg/g), syringic acid (790.92 µg/g), catechin (448.83 µg/g), epicatechin (375.65 µg/g), p-coumaric acid (287.56 µg/g), quercetin (366.98 µg/g), caffeic acid (131.98 µg/g), vanillic acid (113.39 µg/g). Both type of extract demonstrate good antimicrobial activity on Gram negative strains (*S. aureus, E. faecalis, P. mirabilis* and *P. aeruginosa*) and biocompatible with the HaCaT keratinocyte line (Figure 1).

Keywords: by-products recovery, grape pomace, bioproducts, polyphenolic extracts, circular bioeconomy

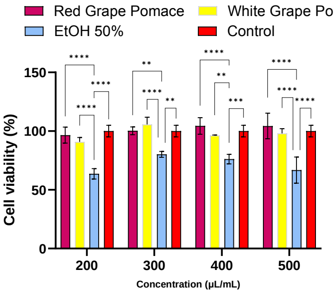

Figure 1. Biocompatibility of the functional ingredient obtained from white and red grape pomaces on HaCaT human keratinocyte line evaluated by MTT methods

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Identification of microorganisms involved in leather biodegradation and heavy metal resistance

Manuela Bonilla-Espadas[1], Basilio Zafrilla[2], Irene Lifante-Martinez[1], Mónica Camacho[2], Elena Orgilés-Calpena[2], Francisca Arán-Aís[1], Marcelo Bertazzo[1], María-José Bonete[2]

[1] INESCOP. Footwear Technological Centre, 03600, Elda, Alicante, Spain; (M.B.E.). Electronic address: mbonilla@inescop.es
[2] Departamento de Bioquímica y Biología Molecular y Edafología y Química Agrícola, Grupo Biotecnología de Extremófilos, Universidad de Alicante, San Vicente del Raspeig, Alicante, Spain. Electronic address: mjbonete@ua.es

Abstract:

Most leather uses chromium tanning, posing risks from Cr(III) to Cr(VI). Current metal removal methods have drawbacks, leading to interest in biosorption, bioaccumulation, and biotransformation. Tanned leather waste needs sustainable management, as per EU Directive (2018/850), favoring alternatives like composting and biological remediation methods; biosorption, bioaccumulation, and biotransformation, offering more sustainable solutions. This study identifies microbial genera capable of degrading different types of tanning agents and analyzes which ones act in different stages of degradation. Eight microorganisms present in tannery wastewater have been identified and isolated; over 10,000 species have been identified in the microbial composition of the initial inoculum (tannery water and municipal water) used for a leather biodegradation assay according to ISO 20136; and changes in microbial diversity during the degradation process of different types of tanned leather have been studied. Acinetobacter, Brevundimonas, and Mycolicibacterium have been the most identified genera for all types of tanning agents, being potential microbial candidates to enhance leather biodegradability, wastewater treatment, and heavy metal bioremediation in industrial applications.

Keywords: biodegradation, bioremediation, tannery water, leather, tanning, compostability, heavy metal.

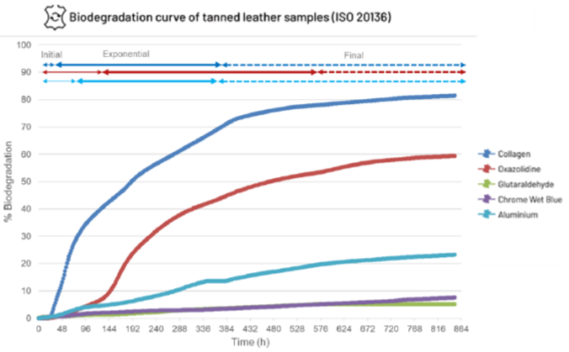

Figure 1: Biodegradation results of the ISO20136 assay performed with four different types of 307 leather samples. The graph shows the biodegradation % vs time of each sample. Collagen is the positive control.

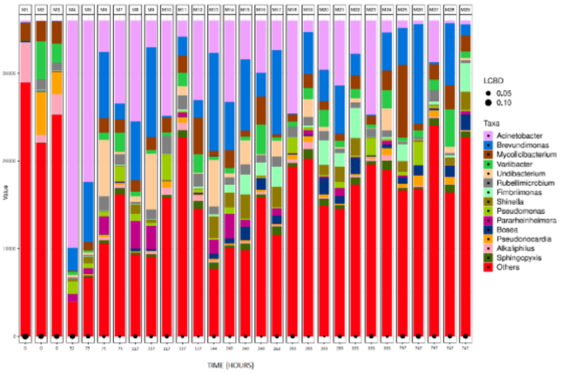

Figure 2: Bar plot figures representing the proportions of detected bacterial genera in all extracted samples of an ongoing leather biodegradation assay(M1 is municipal residual wastewater, sample M2 is tannery wastewater. Inoculum used in assay M3 (50:50 mixture of M1 and M2). Samples as follow; M4, M5, M8, M14, M21 and M25 pure collagen, M11, M19, M24, M28 chromium tanned leather, M10, M18, M23, 493 M27 glutaraldehyde tanned leather, M6, M9, M13, M15, 510 M17, M26 oxazolidine leather and M7, M12, M16, M20, 529 M22, M29 aluminium tanned leather.

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Willis coupling in elastic torsional waves

Yiran,Hao [1,2,*]
[1] College of Advanced Interdisciplinary Studies, National University of Defense Technology, Changsha, China
[2] Department of Physics,The Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong,China

Abstract:

While Willis coupling has been originally proposed as the analog bianisotropy for elastic waves in a bulk solid, its realizations are currently limited to airborne sound and flexural waves on an elastic beam[1]. Recently, we have realized Willis coupling for elastic torsional waves on a thin beam by breaking mirror symmetry for a metamaterial atom with local resonance for the particular type of elastic waves[2], which serves as a universal approach in generating Willis coupling. We have experimentally demonstrated the asymmetric reflection that induced by Willis coupling terms, and achieved mode conversion between bending and twisting waves by adding the asymmetry along vertical side of the beam structure. The investigations will be useful for non-destructive testing on pipes and beam structures with torsional waves. As the development of nanoscale elastic wave devices has opened up new avenues for exploring fundamental concepts in wave physics and materials science. It's meaningful to introduce this nonlinearity property into the elastic nanostructures, which also contributes to the development of micro-electro-mechanical systems.

Keywords: Willis coupling, beam, torsional wave, bianisotropy, asymmetric reflection, mode conversion, elastic nanostructure, MEMS system.

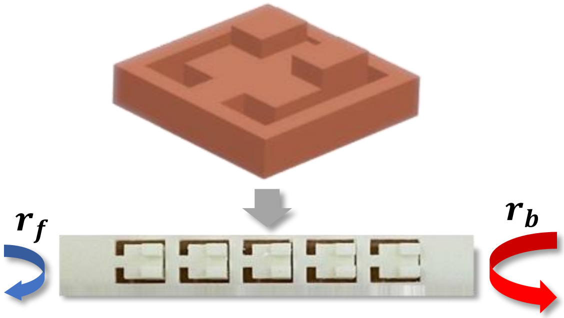

Figure 1: The figure depicts the methodology employed to induce the Willis coupling by breaking the mirror symmetry along the propagating direction. And the presence of Willis coupling terms results in asymmetric reflections.

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Electrosynthesis of nanostructured BiOI-based thin films for improved photoactivation of peroxymonosulfate for water decontamination

A. Serrà [1,2,*], L. Huidobro[1,2,], Q. Bautista[1,2,], E. Gómez [1,2]
[1] Grup d'Electrodeposició de Capes Primes i Nanoestructures (GE-CPN), Dept. de Ciència de Materials i Química Física, Universitat de Barcelona, Martí i Franquès, 1, E-08028, Catalonia, Spain
[2] Institute of Nanoscience and Nanotechnology (IN^{2}UB), Universitat de Barcelona, Catalonia, Spain.

Abstract:

Antibiotic pollution poses a global threat to water ecosystems and human health, driven by continuous releases from various sources. Traditional water treatment methods are often inefficient, necessitating the exploration of advanced oxidation processes (AOPs). Photocatalysis, specifically employing Bismuth oxyiodide (BiOI) thin films, shows promise in degrading antibiotics in water. Electrodeposition emerges as a cost-effective method for scalable BiOI thin film production, providing precise control over film characteristics [1,2].

In this study, we thoroughly examined the BiOI electrodeposition process using a voltammetric analysis of bath components, coupled with an investigation into the chemical composition and structure of the resulting deposits. Following an extensive electrochemical study, it was determined that the application of sufficiently negative potentials induces the reduction of p-benzoquinone, leading to proton consumption and a localized increase in pH near the electrode. This pH increase triggers the precipitation of BiOI on the electrode, forming a thin film. **Figure 1** illustrates the cyclic voltammetry of the solution, showing an initial reduction current starting at 0.1V, corresponding to the reduction of p-benzoquinone, followed by a subsequent increase in reduction current to -0.4V, corresponding to the reduction of Bi(III) to Bi(0). The electrochemical investigation resulted in various deposits, and we explored the impact of an annealing process in an oxygen atmosphere on the chemical composition, structure, morphology, and optical properties of the materials. Both non-annealed and annealed deposits were examined as activators for peroxymonosulfate (PMS) in the absence of light and under visible-light irradiation for the degradation/mineralization of antibiotics. Our focus was on evaluating PMS activation using visible light for the degradation of common waterborne antibiotics. We emphasized understanding degradation kinetics, optimizing conditions for PMS activation in conjunction with BiOI photocatalysis, and striving for the complete mineralization of antibiotics into inert byproducts.

This study aimed to unveil the synergistic interplay between visible-light-activated PMS catalysis and BiOI photocatalysis, ultimately enhancing degradation kinetics and treatment efficiency. The significance of this research lies in its potential to revolutionize water treatment by establishing a sustainable approach to mineralize antibiotics, thereby improving water quality and mitigating the environmental impact of antibiotic pollution.

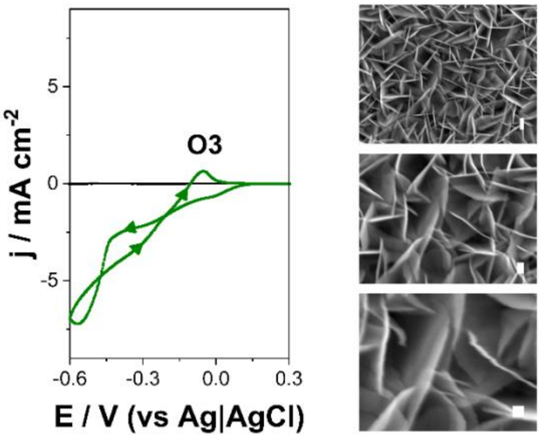

Figure 1: cyclic voltammetry of electrochemical bath and FE-SEM images of BiOI electrodeposits. Scale bar: 100 nm.

Keywords: electrodeposition, BiOI, PMS, photocatalysis, water decontamination.

Acknowledgement: Project PID2020-115663GB-C32 is financially supported by the *Ministerio de Ciencia e Innovación* (MCIN/AEI/10.13039/501100011033).

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Air humidity as a new source of green energy

L. Fernandez Velasco [1,*], A. Bessegmar Carrera [1] , P. Melo Bravo [1], S. Lyubchyk [2], A. Lyubchyk [2], S. Lyubchyk [2].
[1] Department of Chemistry, Royal Military Academy, Brussels, Belgium
[2] Cascatachuva Ltd, Porto Salvo, Lisbon, Portugal

Abstract:

In light of the current climate crisis, coupled with stringent European laws aimed at reducing carbon emissions [1], there is an urgent need to explore alternative sources of green energies. In this context, air humidity is a vast and sustainable reservoir of energy that, unlike solar and wind, is continuously available. This technology is particularly advantageous for remote locations where traditional power infrastructure is impractical and it offers an auxiliary power source suitable for self-sustaining buildings, portable electronics, and other decentralized energy systems. Building upon this idea, CATCHER project [2] is developing a technological solution for the direct conversion of the humidity adsorption energy to electrical energy thanks to the functional heterojunction effect. That is a chain of physicochemical, physical, and electrophysical processes formed between advanced nanomaterial particles-adsorbate surface and adsorbed water molecules from the air (Figure 1).

In this work, the performance of zirconia nanopowders in water sorption has been evaluated in different conditions and linked to their textural and surface properties, allowing the optimization of the synthesis variables (temperature, pressure, nature and concentration of dopants…). In this regard, it has been shown that charged ions (protons and OH groups) moving along porous channels participate in the charge transfer to the contacts, and the greater the number of channels in the converter structure, the greater the voltage on the load.

In this manner, a material able to significantly adsorb water vapour molecules and generate electricity from a relative humidity of 40% has been advanced. The next step in this investigation is to scale-up the converter prototype and reach a TRL5 maturity level.

Keywords: : humidity to electricity converter, renewable energy, functional heterojunction effect, zirconia nanopowders, porous architecture, dopants.

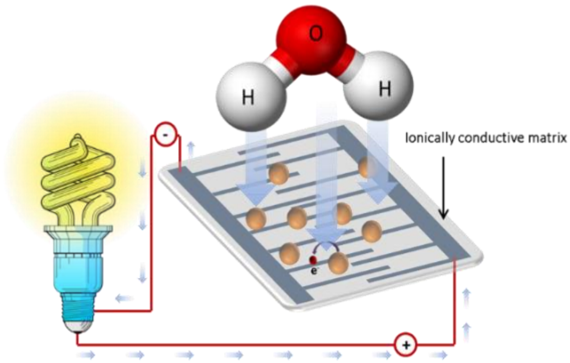

Figure 1: Basic principle of the CATCHER project: the operation of the converter is governed by multiple mechanisms, including the adsorption and dissociation of water molecules, the generation of streaming potential as these molecules and ions move through the converter's porous structure under the influence of internal gradients, and the separation of charges.

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Acknowledgment

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Use of alumina nanoparticles to mitigate solid particle impact erosion in polymeric composite material for leading edge of wind turbines.

L E Ramirez Peña[1], C Mejía-García[1], A M Paniagua-Mercado[1], M Tufiño Velazquez[1], A S De Ita-De la Torre[2].
[1] Instituto Politécnico Nacional, Escuela Superior de Física y Matemáticas, Sección de Estudios de Posgrado e Investigación, CDMX, México.
[2] Universidad Autónoma Metropolitana-Azcapotzalco, Depto. Materiales, CDMX, México.

Abstract:
In this study, solid particle impact erosion was notably observed in the blades of a vertical axis wind turbine, in the case very particles in the leading-edge part, which thereby significantly decreases the efficiency of the wind turbine. To reduce this erosion due to solid particle impact, in this case, silicon carbide with a size of 120 micrometers is used, then the incorporation of alumina nanoparticles of 20 nm in size was carried out at different percentages of 0.2%, 0.4%, 0.6%, 0.8%,1% within an epoxy resin and a bidirectional 0/90 class E glass fiber. The experimental part was carried out as follows, for the characterization of the hardness of the material, 25 mm square specimens with a thickness of 1 mm with different percentages of nanoparticles, where for each specimen 5 measurements were made in different areas of the specimen where the measuring instrument is a durometer (Hardness Vicker), for the tension test a universal machine with tension jaws where the ASTM3039 standard was used where the dimensions of the specimens with different percentages of nanoparticles with dimensions 250mmx25mmx1mm and finally in order to have the loss of material and be able to evaluate the damage, a sandblast was used where it has silicon carbide as eroding solid particle with a measurement of 120 micrometers, where rectangular specimens of 200mmx25mmx1mm were used with different percentages of nanoparticles, where the impact angle was 90°, with an impact pressure of the solid particle of 5 kPa with a maximum duration of 300 seconds, where every 60 seconds the specimen was weighed to measure the loss of material. To identify the areas of erosion damage, a Scanning Electron Microscope (SEM) and Atomic Force Microscopy (AFM) were used. The loss of material decreases by 19 g in a time interval of 300 s using 1% nanoparticles compared to the standard specimen (0% nanoparticles). The result was that an increase in hardness of 2.08 HV was obtained using 1% nanoparticles compared to our standard specimen and finally the mechanical properties of the specimen were improved at the Ultimate Stress Tensil (UST) of 1.3kN using 1% nanoparticles compared to the standard test tube.

Keywords: solid particle, SEM, nanoparticles, AFM, ASTM3039, Hardness Vickers,

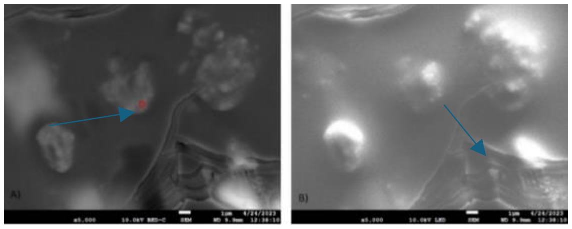

Fig.1 Nanoparticle agglomeration, material wear and composite fractures.

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Synthesis of Au Nanoparticles by Green Method Using Jacaranda Flowers

Concepción Mejía García[1*],Gerzain Jaimez Layna[1],Luis Esteban Ramirez Peña, Elvia Díaz Valdés[1],
Gerardo S. Contreras Puente[1], Ángel Guillen Cervantes[2], María de Lourdes Rojas Morales[3].

[1]Departamento de Física, Escuela Superior de Física y Matemáticas, Instituto Politécnico Nacional,
Avenida Instituto Politécnico Nacional s/n Edificio 9 Unidad Profesional "Adolfo López Mateos" Col.
San Pedro Zacatenco, Gustavo A. Madero, 07738 Ciudad de México, México.
[2]Departamento de Física, Centro de Investigación y de Estudios Avanzados, Instituto Politécnico
Nacional, 07360, Ciudad de México, México.
[3]Laboratorio Nacional de Servicios Experimentales, Centro de Investigación y de Estudios Avanzados,
Instituto Politécnico Nacional. Col. San Pedro Zacatenco, 07360, Ciudad de México, México.

Abstract:

In this work, gold nanoparticles (Au-NPs) were synthesized by green synthesis method, using jacaranda extract and concentrations of 1mM, 5mM and 10mM gold tetrachloride during constant stirring. The synthesized nanoparticles were structurally, optically and morphologically characterized by XR Diffraction, UV-Vis and Transmission Electron Microscopy (TEM), respectively. XRD patterns showed peaks at 38.96°, 44.35°, 64.59° and 77.59° corresponding to Au. The surface plasmon resonance peak in absorption spectra on gold colloidal solution showed absorption from 551 nm to 552 nm. TEM measurement provided an average particle size for the concentrations of 1mM, 5mM and 10mM of 4.6, 5.46 nm and 5.51 nm, respectively.

Keywords: Au-NPs,XRD, TEM, UV-vis, Green Methods.

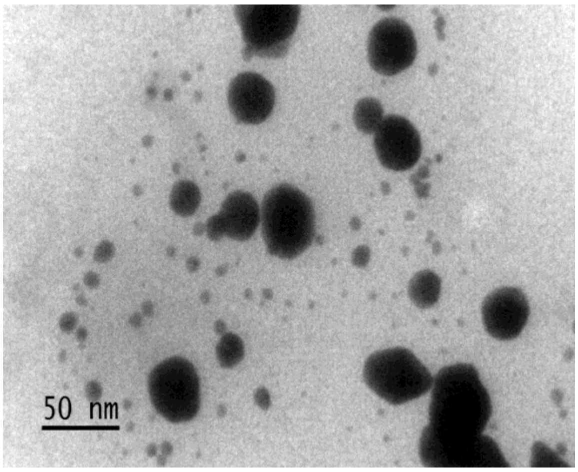

Figure 1: TEM imagen of Au-NPs for the concetration of 10 mM with an average particle size of 18.3 nm for large nanoparticles and an average particles size of 5.1 nm for small nanoparticles.

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Plant Nanofactory: Toward green synthesis of inorganic nanoparticles

Y. AMAN [1]
[1] University Félix Houphouet Boigny, Abidjan, Ivory Coast

Abstract:

The unique morphological (shape, size, and charge distribution) and physicochemical properties of nanomaterials leads to considerable differences in mechanical properties, melting point, optical absorption, thermal, electrical conductivity, biological, and catalytic activities. As such, synthesis of nanoparticles has underpinned great interest due to their novel properties as compared to their bulk counterparts. “Green” synthesis has gained extensive attention as eco-friendly method for synthesizing a wide range of materials/nanomaterials including metal/metal oxides nanomaterials, hybrid materials, and bioinspired materials. As such, green synthesis is regarded as a safe, simple, sustainable, and cost-effective alternative tool in comparison with traditional methods of synthesis. In our investigation, we report for the first time the direct synthesis of inorganic ZnS nanoparticles from biological extract of brown algae collected on West Africa seashore. The synthesis mechanism is discussed according the different experimental characterizations (XDR, SEM, TEM, FTIR, HPLC). In this work, we highlight the role of secondary metabolites in the sequestration of atomic Zn prior to nucleation of ZnS nanocrystals. Herein, we enlight the enumerable potential of plants as sustainable intermediates for the synthesis of nanoparticles.

Keywords: Nanoparticles, Macroalgae, Metabolites, biosynthesis, innovative synthesis

Sacrificial 3D Printing to Fabricate MXene-Based Wearable Sensors with Tunable Performance

Amr Osman[1], Hui Liu[2], Jian Lu[1, 2, 3, 4, 5]
[1] Department of Materials Science and Engineering, City University of Hong Kong, Kowloon, Hong Kong, China
[2] Department of Mechanical Engineering, City University of Hong Kong, Kowloon, Hong Kong, China
[3] CityU-Shenzhen Futian Research Institute, Shenzhen, China
[4] Hong Kong Branch of National Precious Metals Material Engineering Research Center (NPMM), City University of Hong Kong, Kowloon, Hong Kong, China
[5] Centre for Advanced Structural Materials, City University of Hong Kong Shenzhen Research Institute, Greater Bay Joint Division, Shenyang National Laboratory for Materials Science, Shenzhen, China

Abstract:

Wearable sensors are becoming a vital element of newly developed smart devices for their significant prospects in health monitoring, motion detection, and human-machine interactions. Introducing a cost-effective strategy to fabricate pressure sensors with high sensitivity, compressibility, recoverability, and linearity, while also maintaining control over the structure, poses a challenge in developing scalable and high-performance wearable devices. In this study, a fused deposition modelling (FDM)-assisted dip coating is employed to fabricate highly porous pressure sensors with gyroid topologies derived from 3D-printed sacrificial molds (Figure 1). A layer-by-layer dip coating is proposed to achieve a uniform conductive layer over elastomer-based scaffolds using negatively and positively charged MXene nanosheets. The resulting porous sensor, based on self-assembled MXene, demonstrates high sensitivity (9.859 kPa^{-1}) within an extensive linearity range of up to 50 kPa, negligible hysteresis, good stability over 1750 cycles, breathability, and washability. Additionally, the sensor exhibits high temperature sensitivity (4.349% $°C^{-1}$) with superb linearity (up to 100 °C), rendering it suitable for real-time temperature monitoring. By tuning the lattice structure of the sensors, the pressure sensitivities can be significantly improved to 34.43 kPa^{-1} and 84.47 kPa^{-1} within pressure ranges of 12–34 kPa and 34–55 kPa, respectively. The unique sensing mechanism of the gyroid-derived sensor is typically originated from its bending-dominated deformation mechanism, which is clarified in detail through *in situ* SEM and finite element analysis. The pressure sensor exhibits promising potential in diverse applications, including pulse rate monitoring, phonation, motion tracking, and real-time spatial pressure mapping.

Keywords: 3D printing, wearable sensor, MXene, porous structures, motion detection

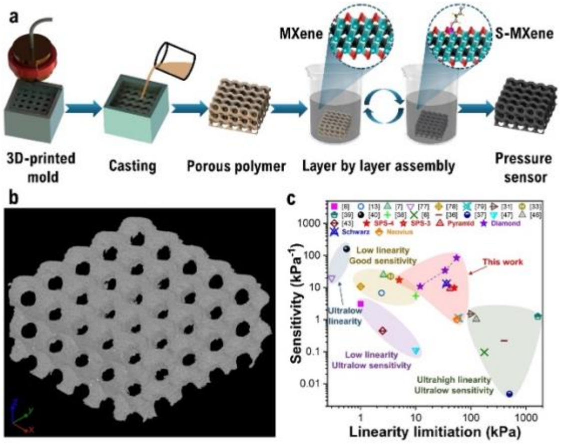

Figure 1: (a) Schematic illustrating the preparation process of the pressure sensor. (b) Micro-CT image of the prepared gyroid scaffold. (c) Comparison of the sensitivity and linearity limitation of the prepared pressure sensors with those recently reported in literature, highlighting the sensor tunability.

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